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ENGLISH LITERATURE

From Its Beginning
in the Sixth Century
To the Present Time

THE LIVING OUTCOME OF
THE LIVING MIND FOR
FOURTEEN HUNDRED YEARS

ALL THE MASTERS OF ENGLISH PROSE AND POETRY

DESCRIPTIONS OF
STYLES AND WORKS

BY

J. P. Lamberton, A. M.

THE VOLUME
ON
ENGLISH LITERATURE

has been specially prepared by one of our most eminent scholars and authors. It furnishes a complete education for all who desire acquaintance with the

MIGHTY MEN OF LETTERS

who have perfected our language and added lustre to English authorship.

THE ERAS OF LITERARY CULTURE

are clearly outlined, and the careers of all the eminent writers are given in connection with their styles and works. Among a few of the very many with whom we are made familiar are:

The Venerable Bede (born 672)
John Wiclif (1324-1384)
Geoffrey Chaucer (1340-1400)
Edmund Spencer (1552-1599)
William Shakespeare (1564-1616)
Ben Jonson (1573-1637)
Sir Philip Sidney (1554-1586)
Francis Bacon (1561-1626)
John Milton (1608-1674)
Samuel Butler (1612-1680)
John Dryden (1631-1700)
John Bunyan (1628-1688)
Daniel Defoe (1661-1731)
Jonathan Swift (1667-1745)
Alexander Pope (1688-1744)
James Thompson (1700-1748)
Thomas Gray (1716-1771)
Oliver Goldsmith (1728-1774)
William Cowper (1731-1800)
Robert Burns (1759-1796)
William Wordsworth (1770-1850)
Walter Scott (1771-1832)
Samuel T. Coleridge (1772-1834)
Thomas Moore (1779-1852)
Lord Byron (1788-1824)
Thomas Carlyle (1795-1881)
Thomas B. Macaulay (1800-1859)
Alfred Tennyson (1809-1892)
Robert Browning (1812-1889)
Mathew Arnold (1822-1888)
William M. Thackeray (1811-1863)
Charles Dickens (1812-1870)
George Eliot (1819-1880)
Ian Maclaren (1850 ——)
Rudyard Kipling (1865 ——)
Mrs. Humphrey Ward (1851 ——)

ONE MISSES THE OPPORTUNITY OF A LIFE-TIME WHO FAILS TO LEARN OF THESE EMINENT WRITERS, AS THEIR LIVES, STYLES AND WORKS ARE HERE PRESENTED.

ENGLISH LITERATURE

THE ENGLISH LANGUAGE. ITS EARLIEST LITERATURE.

A. D. 500—1200.

THE ENGLISH LANGUAGE. The twentieth century has opened with the English Language the dominant speech of the world. The primitive monosyllabic Chinese may be spoken by a larger number of people; the Russian, the Spanish and other civilized tongues may be widely diffused. The Latin, once the language of imperial Rome, is still preserved throughout the world in the service of the Catholic Church; the French remains the language of diplomatic intercourse; the German has, by the studious diligence of its race, become the arena of science and multifarious learning; yet the English, through the indomitable energy of the people who speak it, moves steadily forward to an assured triumph, drawing men of all races under its potent sway.

CHAPTER I.

The English Language. Its Earliest Literature.

A. D. 500—1200.

In history an English-speaking people is first dimly discerned when it wins by hard struggles a new home in a small fair island almost beyond the limits of Roman civilization. It needed centuries to establish itself firmly there, yet eventually it has pushed far beyond and taken imperial rank among the mighty factors of human progress. It has crossed the trackless ocean, founded in a New World an empire vast as that of the ancient Romans, planted colonies not only in the North Temperate Zone but beyond the equator in the Southern Hemisphere, established its dominion in the most ancient seats of civilization and erected outposts in every grand division of the habitable globe. The English language has become the familiar speech, the vernacular, of men of every race and every color. In this triumphant march, sweeping over land and sea, over continents and islands, the English language has lost none of its original worth, its pristine dignity; rather it has increased and magnified the elements of its true greatness and real grandeur. It is to-day more serviceable, more noble, more worthy of love and admiration than it has ever been before. In the fourteen centuries of its recorded history it has undergone many notable changes, but it has lost nothing of permanent value. It has acquired strength by activity and gained power by conquest. It enriches all that inherit it or willingly accept it. Its accumulated literature is a priceless boon, an inexhaustible treasure.

Its Origin.—British conquests in India in the eighteenth century led to the thorough study of the languages of that peninsula. The most astonishing result of this investigation was the discovery that nearly all the languages of Europe are closely related to the Sanskrit, the ancient sacred language of India. This family of languages is therefore called Indo-European. It comprises Sanskrit, Zend (the ancient language of Iran or Persia), Greek, Latin, Lithuanian, Teutonic and Celtic, and their various derivatives in modern European languages.

By further research it has been discovered that the Teutonic group comprises two branches—the east Germanic branch, to which belong the old Gothic and the present Norse, and the west Germanic branch, divided into High German and Low German. The High German prevailed in Central Germany, the Low German in the tribes along the northwest coast from Jutland to northern France. The present representative of Low German is the Dutch, and to this the earliest known form of English, commonly called Anglo-Saxon, but more properly Old English, bears strong resemblance. This remarkable kinship of language, ancient and modern, is a lasting result of the great migration of tribes and races from Central Asia westward through Europe.

The Celts in Britain.—The Celtic race was the vanguard of this movement, and long before the Christian era had occupied the Atlantic coasts from Spain to the British Isles. When the Romans had subdued those regions, they allowed the native inhabitants to remain. Those in Spain and Gaul accepted the language, arts and institutions of their conquerors. But in Britain, though the Romans built towns and roads and kept military possession for more than three centuries, the natives retained their own language, which still survives in Wales and the Scotch Highlands, as well as in Ireland. The British youth were employed in the Roman armies, but on the Continent and not in defense of their own country. The people lost their patriotism when their tribal system was broken up, and depended on the legions of the empire for protection. But the huge empire became unwieldy and many aspirants grasped at supreme power. As its vigor declined, the legions were withdrawn from Britain and the natives were left exposed to the inroads of more hardy tribes.

The Teutonic Invasion.—Before the Romans left Britain piratical adventurers from the German tribes had already harassed and plundered the east coast, so that it became known as the Saxon shore. About the middle of the fifth century these invaders began to take possession of the land. The Jutes from Jutland, who had been most prominent among the sea-rovers, now settled in Kent. They were soon followed by the Saxons, who seized the lands on the south coast and around the Thames. North of these the Angles, who even then called themselves English folk, settled in Norfolk and Suffolk, and in Northumbria. The migratory expeditions continued for a hundred and fifty years. To all these Teutonic tribes the Celts gave the name *Sassenach,* as the Irish do to this day. Yet the invaders, when in course of time they united their forces, used as a common designation Angles, which in Latin became Angli. Rarely did they use the compound term Anglo-Saxon, which has attained prominence in recent times. The bold invaders were all heathen, worshipers of Woden and Thor, whose names are preserved in Wednesday and Thursday. Fierce and brutal in war, they slaughtered or drove out the previous settlers. These Celts had become Christians, and being enfeebled by the Roman dominion had lost much of their prowess. The remnants of them sought refuge in Wales and other corners of the island.

The Dawn of English Literature.—The self-reliant English invaders kept their own language and customs free from admixture. They set up several independent kingdoms. Rude as they seemed, they were not entirely unversed in arts. They had brought from the Continent not merely war-songs, but fragments of long poems, skillfully constructed. These were chanted or recited at their feasts, and new songs were composed by their poets, called scops, that is shapers, or gleemen. There is no trace of Christianity in their poems till the conquest of the land was completed. From far distant Rome came the new impulse. Gregory the Great, when a deacon, had been attracted by the beauty of some captive English boys exposed for sale in that metropolis. When he was told that they were *Angli,* he replied, *"Non Angli, sed Angeli;"* not Angles, but angels. When he became Pope he did not forget the handsome heathen, but sent a missionary to their land. In A. D. 597 the monk Augustine arrived in Kent and at once made a favorable impression on King Ethelbert, who had married a Christian princess from a Frankish tribe. Ethelbert accepted the new faith, and his courtiers followed his example. Yet Christianity spread but slowly among the independent, warlike people. In the North some missionaries came from Iona, where Columba, an Irish Scot, had founded a colony of Christian monks. A similar monastery was established by Aidan in Holy Island, off the coast of Northumbria, and several others on the mainland became schools for the clergy and nobles. It was by these monks that English was cultivated for literary purposes and some of the old heathen poems preserved, though evidently in modified form.

The Traveler's Song.—Perhaps the oldest English poem is *Widsith,* meaning "far away." It seems to have been composed in the fifth century by a North German minstrel who in the fourth had wandered over many lands and visited the courts of powerful kings. The conclusion of his poem has been thus rendered in modern English, which gives the sense but does not reproduce the ancient metre:

So have I ever found, in journeying,
That he is to the dwellers in a land
The dearest to whom God gives, while he lives
Here upon the earth, to hold rule over men.
Thus wandering, they who shape songs for men
Pass over many lands, and tell their need,
And speak their thanks, and ever, south or north,
Meet some one skilled in songs and free in gifts,
Who would be raised among his friends to fame
And do brave deeds till light and life are gone.
He who has thus wrought himself praise shall have
A settled glory underneath the stars.

Beowulf.—Other poems of some merit have been preserved, but the greatest interest has been aroused by the Old English epic which recites the brave deeds and death of Beowulf. This hero, thane of Hygelac, is said to have sailed from Sweden to the aid of Hrothgar, king of Jutland, who had been harassed for twelve years by a grisly monster, Grendel, dwelling in a marshy lake near the sea. The evil passions of this fiend had been roused by the festivity at the opening of the king's new hall, Heorot. Therefore at night he broke into the hall, carried off one of the thanes who had been sleeping on benches, and devoured him. This outrage had been repeated at intervals until thirty victims had been destroyed. Then the hall was deserted and its fate was made known widely in songs. Beowulf was thus stirred to seek an encounter with the invulnerable monster. When his errand was learned by Hrothgar he was warmly welcomed. He undertook to guard the hall, and when the fiend entered at night engaged in a deadly struggle without weapons. At last Beowulf succeeded in tearing off a limb of the monster. The fiend fled to the lake. On the next night came his sea-wolf mother, seeking vengeance. Quickly she slew another thane, the dearest friend of Hrothgar. Then the king urges Beowulf to attack the monsters in the lake. The hero, donning his armor, descends to the bottom of the lake. Here he encounters Grendel's mother, and slays both her and her son. He discovers also a precious treasure in a cave, but neglecting it, carries off the heads of the monsters. Through a sea of blood he swims to rejoin his friends. In the hall he relates his exploits, which Hrothgar abundantly rewards. The gleeman celebrates the deed in a new song and the thanes resume their revelry, shouting "Heorot is ransomed." When Beowulf departs Hrothgar gives him a well-equipped vessel, and Beowulf, in return, presents the king with a jeweled sword.

Many years later Beowulf, who has been made king of the Danes, engages in another adventure with a fiery dragon, the guardian of a hidden treasure. Believing he is destined to perish in the conflict, he rehearses his past life. His sword is broken on the scaly hide of the dragon, but a comrade stabs the beast. Beowulf, however, is mortally wounded, and the poem closes with his funeral.

This legend seems to have been put into English verse in the seventh century, and is thus the most ancient heroic poem in any Germanic language. It comprises 6,357 lines. The weird tale is evidently a mythical treatment of an historical event otherwise unknown. The solitary manuscript containing it lay neglected in England until Thorkelin, a Danish antiquary, seeking materials for his country's history, discovered and published it in 1815. Then its value was perceived, and it aroused great interest in Germany and England, as well as Denmark. It may originally have consisted of short poems about the hero, which were combined and edited by a Northumbrian poet. To him are due a few Christian touches, while the main poem is thoroughly pagan.

Caedmon.—When Christianity was fairly accepted by the people a new spirit entered into English poetry, though the warlike spirit was not lost. In the new songs of victory the triumph is ascribed to God. The fondness for the supernatural was now shown in legends of saints and Christian heroes, as well as in paraphrases of Bible story. The most celebrated name in this connection is Caedmon, whose career is chronicled by the venerable Bede in his Latin history. Caedmon was a lay brother at the monastery of Whitby, founded in A. D. 657 by Hilda, a royal convert from paganism. When, according to custom, the harp was passed round among those gathered for pleasure in the evenings, he would depart, as he knew no song. But once, when he had thus gone out to the stables, he fell asleep. In his dream he heard a voice bidding him sing, and he replied that he could not sing. The speaker insisted that he should. "What shall I sing?" said Caedmon, and the other replied, "Sing the origin of creatures." At once the layman was inspired to sing verses to this effect:

> "Now ought we to praise the Author of the heavenly kingdom, the power of the Creator and His counsel, the deeds of the Father of glory: how He, being the eternal God, became the author of all marvels: the Almighty Guardian, Who created for the sons of men, first, heaven for their roof, and then the earth."

On awaking, Caedmon repeated these verses and composed others. He was led to the abbess, who bade him rehearse his dream and then versify a portion of sacred history read to him. When this was done she advised him to become a monk, that he might read and versify the Scriptures.

Such is the account given by Bede, and there are extant paraphrases of Scripture story bearing Caedmon's name. The best critics think that only a few lines really belong to him, and that the work is due to several authors. The most spirited part is that called *Genesis,* in which the poet describes Satan's expulsion from heaven as Milton did a thousand years later. The root idea, however, is found in earlier Christian interpreters of Scripture. Another fragment which was found in the same manuscript with Beowulf relates in spirited style the story of Judith, the Jewish maiden who yielded to embraces of Holofernes that she might slay that enemy of her people.

Cynewulf.—Some other Christian poems of this period have been found with the name Cynewulf inserted in runes, which were the early alphabetic characters of northern Europe. The longest of these was *Elene,* which tells the legend of the finding of the true cross by Helena, the mother of the Emperor Constantine. Another described the *Coming of Christ,* and a third related the legend of St. Juliana. Joined with these are many riddles, probably originally a hundred, though only about ninety remain. It was the fashion in those days for Latin writers to compose centuries of riddles, and this English poet imitated them in his native tongue, translating freely from theirs. They are of various lengths, from four lines to a hundred. The riddles are not mere puzzles, but often highly poetical descriptions of the wonders of nature.

Characteristics of Old English Poetry.—The early English verse differed essentially from that of the present day. It has no rhyme, nor any fixed number of syllables in a line. The chief features are accent and alliteration. Each line has four accented syllables and there is a pause about the middle. Two of the accented syllables in the first half and one in the second usually begin with the same consonant, but sometimes these accented syllables begin with different vowels. This system of alliteration is not always strictly observed. The variation seems to be intentional, according to the nature of the subject. A short extract from Caedmon's *Genesis* will sufficiently illustrate Old English rhythm; the mid-verse pause is marked by a colon.

Thegnas thrym-fæste: theoden heredon,
Sægdon lustum lof: heora lif-frean
Demdon drihtnes: dugethum.

This obsolete English needs a translation for readers of the twentieth century.

Thanes most glorious their leader honored,
Told with pleasure praise to their life-king,
Ruled the Lord's nobility.

A striking peculiarity of this Old English poetry is the substitution of figurative expressions and compound words for the names of persons and things. Thus, the ocean is called the *whale's path;* an arrow becomes a *war-adder,* Noah's ark is called the *sea-house,* and, again, the *palace of the ocean.* Another feature was the frequent use of inversion in sentences.

The Venerable Bede. — The introduction of Christianity gave the English people acquaintance with Latin, the language of the Church service, but hardly with Latin classical literature. The fathers of the Church showed scant favor for the remains of Pagan antiquity, but they imposed the use of Latin on all the youth whom they trained. The greatest literary character of the Old English period was Beda, usually called the Venerable Bede (673-735). He was a monk at Jarrow, in Northumbria, devoting his time entirely to learning, teaching and writing. His forty-five works were all in Latin. Though he is reported to have been engaged at the time of his death in translating the Gospel of St. John into English, no trace of such translation remains. But his chief work was *The Ecclesiastical History of Our Island,* in which he recounts the history of Britain from the time of Julius Cæsar. To him we owe the story of Caedmon which has been related above, as well as much of the secular history of Britain. King Alfred, a hundred and fifty years later, turned parts of Bede's history into Old English or Anglo-Saxon for the benefit of his countrymen.

Alfred the Great.—Early in the ninth century the fierce piratical Danes threatened the extinction of the English people. They seized Northumbria and all the east of England and drove the rulers of Wessex into the swamps. Yet when the Saxon power was at its lowest ebb, the genius of Alfred the Great (849-901) found means to turn the tide of fortune. Gathering again the scattered, disheartened Saxons, he defeated the Danes and made a treaty relinquishing to them a large territory, but compelling them to keep within bounds. Then applying himself with wise statesmanship to the arts of peace, he undertook the education of his own people. Wise and learned men were drawn to his court, and schools were established for noble youth. For their better instruction the king caused what were considered the best works of the time to be translated into English. Among these were Pope Gregory's *Pastoral Care,* Orosius' *Universal History,* and Bede's history, already mentioned. The king himself took part in the task of translating. In the history of Orosius he inserted the narrative of some Norse sailors as told to himself. His rendering of Bede was the first English history of the English people. His *Code of Laws* tended to unite and elevate the distracted people. His was indeed a strenuous life; and when, at the age of fifty-two, death drew near, he wrote: "As long as I have lived I have striven to act worthily. I desire to leave to those who come after me a remembrance of me in good works." After the lapse of a thousand years England still delights to honor the memory of this wise ruler and benefactor.

The Saxon Chronicle.—Alfred set in motion another work which kept the scribes busy long after his death. He caused a history to be compiled, and copies of it to be sent to the principal monasteries. It gave a brief outline of events from the invasion of Julius Cæsar to Alfred's own time. His exploits were related modestly yet graphically. The monks were directed to continue these annals, entering all-important events as they occurred. In one of the copies still extant the history is brought down to A. D. 1150, almost a hundred years after the Norman conquest. In some places the monks inserted amid the usual dry statements poetical descriptions of stirring events. Hence we have the ballad of the battle of Brunanburh, A. D. 957, which Tennyson has modernized without losing its antique flavor. Here is the opening stanza:

Athelstan King, Lord among Earls,
Bracelet-bestower and Baron of Barons,
He, with his brother Edward Atheling,
Gaining a life-long glory in battle,
Slew with the sword-edge, there by Brunanburh,
Brake the shield-wall, hew'd the lindenwood,
Hack'd the battle-shield,
Sons of Edward with hammer'd brands.

Layamon's Brut.—The Norman conquest caused a suspension, almost an extinction, of Old English writing. The clergy still kept up their Latin, but at court and castle the fashionable language was Norman-French. Yet the people never gave up their native tongue, as many peoples on the Continent had done. The *Saxon Chronicle* attests the continued use of the language. The swan song of Old English literature is the long alliterative poem called *Brut.* It was written about A. D. 1200 by a priest named Layamon, who dwelt near Wales. It was indeed an English version of a Norman poem written about fifty years earlier, and that, in turn, was drawn from the Latin history of Geoffrey of Monmouth. It is a curious recast of the history of Britain, partly derived from the traditions of the British Celts and partly drawn from stories found in ancient Roman history and poetry.

According to it Britain, which had originally been called Albion, derived its name from Brut or Brutus, a descendant of Æneas, who had unfortunately, yet innocently, caused the death of both his parents. Exiled therefore from Italy, he had wandered in many lands, but finally reached Albion, his predestined home and kingdom. Besides this parody of Vergil's story, the poem contains legends of King Arthur and Merlin, and outlines of the stories of Cymbeline and Lear. Here, in the conclusion of Old English literature, we find a wonderful blending of long-lost Celtic imaginative elements with sturdy Saxon self-reliance and love of fact. Later, in the loftiest achievements of English literature from Shakespeare to Tennyson, will be observed the same blending of the ideal with the real, of poetry and truth.

CHAPTER II.

Middle English Literature.

From Chaucer to the Introduction of Printing.

A. D. 1300—1500.

The Norman Conquest.—It took more than five hundred years to transform Britain into England, and even then the work was not complete. The Teutonic tribes, though of common origin, had not become thoroughly united. Northumbria, which was the seat of the earliest literature, held aloof from Wessex (West Saxony). The tremendous invasion of the Danes in the ninth century threatened a return to chaos. Alfred, after defeating them, made a treaty allowing them possession of a large territory. In the eleventh century Saxon kings lost their power and the Danish Cnut (or Canute) became king of England and ruled wisely. But his successor was a tyrant, and the people called back Edward the Confessor, a descendant of Alfred, to the throne. Edward had been brought up in Normandy, but was trained for the Church rather than for kingly rule. He introduced Norman customs, which produced discontent. He had promised the succession to William, Duke of Normandy, but his chief minister, the Saxon Harold, actually succeeded and reigned for twelve years. Then William came to enforce his right, and by the bloody battle of Hastings, A. D. 1066, won his place.

So vital a change was wrought by this conquest that for many purposes the history of England takes its beginning from this era. The Normans were of the same stock as the Danes, who had brought terror to England, and in fact to all western Europe. They were Northmen from Norway, who had seized the north of France and had been allowed to keep it. The heathen pirates had become in fifty years French Christians, accepting the language and religion of their new home. When they came into England they introduced the feudal system; the lands were surveyed and entered in the *Domesday Book;* thenceforth they were held by military tenure. To restrain the freedom of the people the curfew kept them in their houses at night. Instead of the old Witenagemot (meeting of wise men) a new Parliament of nobles was called to make laws. Norman French was spoken at the king's court, used in the courts of law, taught in the schools, and employed by the *trouvères* or court-poets. To one of these, Master Wace, is due the poem on Brut, already mentioned. He composed also the *Roman de Rou,* relating the story of Rollo, the first duke of Normandy.

Middle English.—But when the English kings lost their foreign possessions and the noblemen settled down firmly in the island, they were obliged more and more to use the speech of the people. The Old English was enriched with a multitude of new terms required by the higher civilization. It lost many of its grammatical forms, but it retained the useful words in simpler forms. Gradually nobles and peasants, churchmen and laity, came to meet on common ground, to understand each other better, to acknowledge each other's rights, and to use a blended speech. This new form of English is called by scholars Middle English. It prevails in the literature which arose between 1300 and 1500. It is found in Wiclif's translation of the Bible, in Langland's *Vision of Piers Plowman,* and, above all, in Chaucer's *Canterbury Tales.*

John Wiclif (1324-1384) has been called "the last of the Schoolmen and the first of the Reformers." He was highly learned, according to the standard of his time, wrote much in Latin, and supported the king's authority against the claims of the Church. Patronized by the powerful John of Gaunt, he was able to resist persecution. His great legacy to the English people was a translation of the Bible from the Latin Vulgate. This was widely circulated, especially in the improved edition by Purvey.

William Langland (1332-1400).—About the same time Langland gave utterance to the discontent of the lower classes with the oppression of the rich and the corruption of the Church. In the *Vision of Piers the Plowman* the poet falls asleep and beholds a "fair field full of folk." These are plowmen, whose labor goes to feed gluttons, richly clothed merchants, lawyers greedy for gold, pardoners from Rome who delude the people. A multitude set out to seek Truth, but first encounter Falsehood, to whom the fair Lady Meed (or Bribery) is to be married. Theology interferes, and the case is carried to the king in London. Falsehood flees and the king advises Lady Meed to marry Conscience, who at once exposes her misdeeds. Then the king sends for Reason, who gives righteous judgment and is requested to remain in the council. In the end many penitents enter on the search for Truth and find that Piers, who is working in a field, is able to guide them. He insists on finishing his half-acre before setting out. It appears that all who wish to succeed must join in hard work. When the Plowman shows the pardon that he has received from Truth a priest objects and provokes a hot discussion, in the midst of which the dreamer awakes. To this version the poet afterwards made additions called *Do Well, Do Bet and Do Best,* in which Christ appears as Love in the garb of the plowman. This religious allegory was widely spread among the people, and imitations of it soon appeared, testifying that the minds of the people were deeply affected. Langland was the poet of the laboring class, and used the old alliterative verse still dear to them.

PIERS THE PLOWMAN.

"Peter," quoth a Plowman, and put forth his head,
"I know him as kindly as clerks do their books.
Conscience and Kind-Wit sent me to this place,
And made me secure him to serve him for ever,
Both to sow and to set, the while I swink might,
Within and without, to watch on his profit.
I have been his follower all these forty winters,
And served Truth surely, somewhat to please him—
In all kinds of crafts that he could devise.

Profitable to the plow, he put me to learn;
And though I say it myself, I serve to his pleasure.
I get my hire of him well, and sometimes more;
He is the most prompt payer that any poor man knoweth.
He withholds not his hire from his men over even,
He is meek as a lamb and leal of his tongue,
Whoso wisheth to know where that Truth dwelleth,
I will guide you well right to his place."
"Yea, dear Piers," cry the pilgrims, and proffered him pay.
"Nay, by the peril of my soul," Piers gan swear,
"I would not take a farthing for Saint Thomas' shrine!
Were it told to Truth that I took reward,
He would love me the less a long time after.
But whoso will wend where Truth dwelleth,
This is the high way hither, mark well the sooth.
Ye must go through Meekness, all men and women,
Till ye come to Conscience, known of God's self,
That ye love him as lord loyally above all.
That is to say soothly, ye should rather die
Than do any deadly sin, for dread or for prayer.
And then your neighbors next in no wise treat
Other than ye would they treat you all times."

Geoffrey Chaucer.—But the literary glory of the Middle English period was Geoffrey Chaucer (1340-1400). He was born in London and lived there all his life, though he visited France and Italy. At the age of sixteen he became a page at court and at nineteen served in the army in France, where he was taken prisoner and ransomed. Again he was at court and began to write poetry on French models. The most important was the translation of the *Romaunt of the Rose.* Some critics, however, deny his authorship in this. In 1369 he wrote an elegy, *The Dethe of Blaunche the Duchesse,* whose husband, John of Gaunt, was the poet's patron. Chaucer was afterwards employed on diplomatic missions and thriee visited Italy. The lasting effect of these visits is manifest in his poems. Italy had then a fresh and noble literature, and Chaucer evidently studied the great masters, Dante, Petrarch and Boccaccio. Henceforth he rejected the French style and borrowed freely from the Italian writers. Several of the *Canterbury Tales* were composed long before they were brought together in that work. Other poems of this Italian period are the humorous *Parlament of Foules*, the allegorical *House of Fame,* and the pathetic *Compleynt of Mars.*

In later years Chaucer held official places in the customs service at London. The poems of this time are more thoroughly English. New tales and old were arranged and assigned to various characters in his *Canterbury Tales*, for which he composed the *Prologue* about 1388. It excels in its vivid portraiture of the various classes of English people of that time. Good nature and shrewdness are shown in the poet's observations and humor sheds its kindly light over all. In the last ten years of his life he met with some misfortune and wrote with less vigor. The *Parson's Tale,* the only one in prose, was written in the year of his death.

Chaucer's poems are characterized by tenderness and grace. His satire is kindly, his heart is full of sympathy, his desire is to benefit the world around him by pointing out the beauties of human nature rather than scolding its follies. He seems to have been unfortunate in love, yet this does not embitter his spirit. Though of rather humble birth, he associated with the aristocratic class, and always exhibits the character of a true gentleman. His life made him a man of business, a man of the world, without hardening his heart or diminishing his charity for all. Yet he was evidently reserved in company, and in the *Canterbury Tales* he makes the merry host jest on the fact. He was a diligent student, ever engaged in reading and writing when not employed in his daily routine of business. But when spring came after the dreary winter, he loved to go forth in the early morning to enjoy the beauty of the fields and flowers. This love of nature is prominent in his poetry. Yet he was also fond of mirth and good living, liking to see others enjoy themselves, though he took little share in their sport. He knew and loved men as well as books and nature. In some respects Chaucer's life and manner may suggest to an American a likeness to Washington Irving, as a kindly humorous observer of human nature, early disappointed in love, yet preserving a cheerful equanimity to old age.

The Canterbury Tales.—Chaucer's other poems have sunk into insignificance compared with the grand truthful picture of contemporary men and manners which he has furnished in the *Canterbury Tales.* The plan of the work is original and plausible. A company of travelers, twenty-nine in all, gather at the Tabard Inn, Southwark, with the intention of going on a pilgrimage to the shrine of St. Thomas à Becket at Canterbury. Such pilgrimages had become a national custom, and they were occasions of much enjoyment, by the way. After the party had supped together, Harry Bailey, the jolly host, proposes that they should journey together, and that to enliven the travel each should tell a tale, going and returning, and whoever told the best should have a supper at the expense of the rest. The company agreed and appointed the host to be judge. The characters comprised a chivalrous Knight, who has fought in many foreign wars; his son, a gay young Squire; a Yeoman with a nut-head and brown visage; a demure Prioress; a jovial Monk; a merry Friar; a worthy

Merchant; a poor Clerk of Oxford; a Franklin or freeholder; a wanton Wife of Bath; a discreet Serjeant of Law; a good Parson; a wily Pardoner with precious relics; a stout Miller; a Reeve or bailiff; a Summoner, who cited offenders before the church court; a Shipman, whose beard had been shaken by many a tempest; a Cook, a Haberdasher, and other minor characters. Pictures have helped to make many of these pilgrims familiar. It has been well said: "What an intimate scene of English life in the fourteenth century do we enjoy in these tales, beyond what history displays by glimpses through the stormy atmosphere of her scenes, or the antiquary can discover by the cold light of his researches?"

The matchless Prologue is complete, but the full plan of the work was never finished. Not all of the pilgrims tell a story, though each was to tell two, or, as some interpret the proposal, four. The pilgrimage never reached Canterbury, but vanished somewhere on the way thither. Yet it has left the world richer and brighter than it was before, and we gratefully enjoy the radiance. Here we must be content with the touching description of the Parson:

THE PARSON.

(Somewhat modernized in spelling.)

A good man there was of religion,
That was a poore Parson of a town,
But rich he was of holy thought and work,
He was also a learned man, a Clerk,
That Christes gospel truly wouldé preach,
His parishens devoutly would he teach;
Benign he was, and wonder diligent,
And in adversity full patient,
And such he was yproved often sithes;
Full loath were him to cursen for his tithes;
But rather would he given out of doubt
Unto his poore parishens about
Of his off'ring, and eke of his substance;
He could in little thing have suffisance.
Wide was his parish, and houses far asunder,
But he ne left naught for no rain nor thunder,
In sickness and in mischief, to visite
The farthest in his parish, much and lite,
Upon his feet, and in his hand a staff:
This noble 'nsample to his sheep he yaf,
That first he wrought, and afterward he taught,
Out of the gospel he the wordes caught,
And this figúre he added yet thereto,
That if gold rust, what then should iron do?
For if a priest be foul on whom we trust,
No wonder is a lewed man to rust;
And shame it is, if that a priest take keep,
To see a fouled shepherd and clean sheep;
Well ought a priest ensample for to give
By his cleanness how his sheep should live.
He setté not his benefice to hire,
And left his sheep accumbred in the mire,
And ran unto London unto St. Poule's
To seeken him a chantery for souls,
Or with a brotherhood to be withold;
But dwelt at home and kepté well his fold,
So that the wolf ne made it not miscarry:
He was a shepherd and no mercenary;
And though he holy were, and virtuous,
He was to sinful men not dispitous,
Ne of his speeché dangerous ne digne;
But in his teaching discreet and benign.
To drawen folk to heaven with faireness,
By good ensample, was his business;
But if there were any person obstinate,
What so he were of high or low estate,
Him would he snibben sharply for the nones:
A better priest I trow that no where none is.
He waited after no pomp or reverence,
Ne maked him no spicéd conscience;
But Christes lore, and his apostles twelve
He taught, but first he followed it himselve.

Minor Poets.—Three other poets of this period may be mentioned—John Gower (1326-1408) called Chaucer his disciple, and Chaucer, in return, called him "Moral Gower." He wrote a Latin poem, *Vox Clamantis,* which describes the social disorder of his time, and a tedious English poem, *Confessio Amantis,* which treats of the impediments to love, and recites a hundred stories warning against it. John Lydgate (1370-1447), a poor imitator of Chaucer, wrote an allegorical poem, *The Temple of Glass,* and versified legends, fables, and Boccaccio's *Falls of Princes.* Thomas Hoccleve (1368-1450), clerk in a public office, wrote some poems in which he gives humorous sketches of the modest pleasures of his youth.

Sir Thomas Malory.—Better than these poets in modern estimation is the prose of the worthy knight, Sir Thomas Malory, whose *Mort Darthur* has preserved the legend of King Arthur. He says that it was translated from the French in 1469, but much of it seems to be original.

William Caxton.—No history of English literature can be complete without honorable tribute to the memory of William Caxton, who introduced into England "the art preservative of all arts." He was born in Kent about 1422, and engaged in mercantile pursuits first in London and afterwards at Bruges. Yet he had fondness for literature, and made translations from French and Latin. When he translated a French romance on the history of Troy, so great was the demand for copies that he learned the new art of printing, "that every man might have them at once." This *Recuyell of the Historyes of Troy,* the first book printed in English, was printed by Colard Mansion at Bruges in 1471. Then Caxton, who had become proficient, returned to England and set up his press in Westminster Abbey in 1474. Hence to this day a meeting of printers is called a "chapel." Victor Hugo has told how "the Book killed the Church."

But Dean Stanley has suggested that "the Church has given life to the Book."

For seventeen years Caxton labored at the new art, translating and editing most of the ninety-nine issues of his press. The first was *The Game and Play of the Chesse* (1474). Then followed *The Dictes and Sayings of the Philosophers* (1477), *The Mirrour of the World* (1481), *Golden Legend* (1484), *Canterbury Tales* (1484), *Æsop* (1484), Malory's *Birth, Lyfe and Actes of King Arthur* (1485). Caxton printed no Bible, but the *Golden Legend* contained the story of the Gospels and other parts of Scripture. Only thirty-one of his books have been preserved to this day. He died in 1491. His books show him to have been a lover of chivalry; his private character is without a stain. Who can estimate the value of his contribution to human progress?

Scottish Poetry.—The eastern lowlands of Scotland were settled by English people. Old Northumbria, in which English literature first flourished, extended to the Firth of Forth. At a later period, when separated politically from England, the Scotch became aggressive in their assertion of nationality, and this has remained a characteristic of their poetry down to the present day. John Barbour, Archbishop of Aberdeen, published in 1377 a long poem, called *The Bruce,* which recited the deeds of the hero of Bannockburn. James I. of Scotland was a prisoner in England for fourteen years, and there came under the influence of Chaucer's poetry. In *The King's Quhair* (that is quire or book) he closely imitated the father of English poetry. The seven-lined stanza which he adopted from his master has since been called Rime Royal. The six cantos of this poem describe the beginning and happy end of the prisoner's love for Lady Jane Beaufort, niece of Henry IV. It is the purest and most tender poetry in the period between Chaucer and Spenser. Other poems attributed to King James I. are *The Kirk on the Green* and *Peebles to the Play.* They are in the humorous style which Burns has made familiar. Good critics think that they really belong to King James V.

William Dunbar.—Another notable Scotch poet was William Dunbar (1460-1520), who carried on the influence of Chaucer in the sixteenth century. His work was varied and highly original. In *The Thistle and the Rose* (1503) he celebrated the marriage of James IV. to Margaret Tudor. His *Golden Terge* (1508) is an allegory of Love, Beauty, Reason and the Poet. It begins with May morning, the description being of Scottish scenery, and is full of national enthusiasm. But Dunbar was far more original in his satires and ballads, in which fun was mingled with coarseness. *The Dance of the Seven Deadly Sins* is a unique mixture of humor and horror.

Gawin Douglas (1474-1522) was the first to produce in English a metrical translation of any Latin book. He thus translated Ovid's *Art of Love* and Vergil's *Æneid.* To each book of the latter he prefixed a metrical prologue of considerable merit. Three of them are descriptions of Scotch scenery in May, in Autumn and in Winter. Nothing equal to them in landscape painting was done until the Scotchman Thomson wrote his *Seasons* in the eighteenth century. Douglas's other original work was *The Palace of Honour* (1501). This learned poet was the Bishop of Dunkeld, but died in London at the court of Henry VIII.

Sir David Lindsay (1490-1555) was the last of the old Scottish school of poets. His work was highly popular, because he took the side of the Reformers in the great religious controversy. In his *Dreme* (1528) he imitates Chaucer in manner, but the spirit is rather that of Langland, dwelling on the woes of the people. The same spirit is shown in his *Complaynt to the King* and *The Testament of Our Sovrane Lord's Papyngo* (that is, *parrot*), and *Ane Pleasant Satire of the Three Estaits.* The last is a rude dramatic composition, satirizing clergy, nobles and merchants, full of humor and grossness, illustrating the taste of the times. Though foul with indecency, it was acted in the presence of the king's court, the stage being in the open air, in January, 1540. King and queen, lords and ladies, bishops and laymen of all ranks thronged the place. It is pleaded, in excuse for some coarse passages, that they were probably intended to amuse the lower classes at intervals while the more refined audience had retired for refreshments. Let us drop the curtain.

CHAPTER III.

Elizabethan and Other Tudor Literature.

1485--1603.

The Renaissance.—During the fifteenth century the great intellectual movement known as the Renaissance culminated in Italy. It had been excited by the surrender of Constantinople to the Turks in 1453. The Greek scholars of the Eastern Empire sought refuge in the West, bringing with them precious manuscripts of ancient classics and more exact knowledge of the noble language in which they were written. Close contact and familiar intercourse with these masters filled the lovers of learning in the West with fresh enthusiasm. They sought to revive in modern tongues the transcendent genius of Greek antiquity. In poetry and, indeed, in all the fine arts, the effects were soon apparent. The golden age seemed to have returned and was universally acclaimed.

From Italy this movement spread to other lands. The brightest youths of England, France, Spain and Germany thronged the Italian universities and listened to the instruction of the wise men of the East. The invention of printing with movable types vastly helped the diffusion of knowledge. All classes of society were benefited. Soon new discoveries in science were announced. Finally the hardy daring of a Genoese navigator revealed a new world. England was soon able to claim a share in it through John Cabot's discovery of North America in 1497.

Learning in the Tudor Period. — The bloody Wars of the Roses were brought to an end by the defeat and death of Richard III on Bosworth Field in 1485. Henry VII, who then succeeded to the throne, was the first of the house of Tudor. His reign was peaceful and prosperous, but he quelled any lingering discontent by severe measures. William Caxton had been working his press for some years. The histories and romances which he printed stirred the imagination of the people and supplied grand themes for new poets. The wider diffusion of the works of Chaucer prepared the way for the success of Elizabethan literature. The study of the ancient classics improved the culture of readers. Noble and ambitious youth went to Italy to study. Wealthy men collected valuable libraries as books came from the press in different countries. England was as ready to impart as she was to receive the new learning. Erasmus, recognized as the foremost exponent of humanism, learned Greek in England. Throughout the Tudor period the study of the ancient classics flourished and tended to promote the production of equally valuable works in modern English. It should be noted that printing had great effect in settling the standard of good English and securing uniformity. This change was not fully effected until the Bible was translated and the old black-letter type gave way to the clearer Roman. Thenceforth the dialects which prevailed in various districts were confined to speech but discarded in literature.

The Breach with Rome.—Henry VIII was a high-spirited and learned king. In his ardent Catholicism he entered into controversy with Luther and published a book defending the seven sacraments. For this service the Pope rewarded him with the title "Defender of the Faith," still borne by English sovereigns. Alas! how vain are human expectations. In a few years Henry, having no son, sought a divorce from his queen. The Pope refused, and the headstrong monarch not only repudiated his wife, but claimed the headship of the Church in England. The separation from Rome was enforced by pains and penalties even to death.

Sir Thomas More (1478-1535), the Lord Chancellor of England, who had been a warm friend of the king, was put to death because he would not approve Henry's marriage to Anne Boleyn nor acknowledge the royal supremacy. More is best known in literature by his rather dull romance of *Utopia,* which describes vaguely an ideal commonwealth in which religious liberty is allowed. It was written in Latin and published in 1516, and translated into English in 1551. More wrote a history of Richard III, the first history in modern English.

The English Bible.—Wiclif and his disciples had endeavored to give the English people the Bible in their own language, but after the translator was pronounced a heretic his work was suppressed. One hundred and fifty years later William Tyndale (1484-1536) undertook to bestow on his countrymen an exact translation of the New Testament from the original Greek. Unable to get it printed in England, he went to Brabant, and there the book was printed in 1526. It found ready sale, and he went on to translate the Old Testament, publishing the Pentateuch in 1535. But Tyndale had accepted Luther's doctrine and had introduced it into annotations in his Bible. The books were condemned and burned by the Bishop of London, and the translator himself suffered martyrdom. Miles Coverdale, who had been engaged in the same pious work, published the first complete English Bible in 1535. Afterward he went to England, where he enjoyed the favor of the king and of his chief counselors, Thomas Cromwell and Archbishop Cranmer. Henry ordered a copy to be placed in every parish church in England. Later a royal commission, eight of whom were bishops, prepared an improved version. All of these early Bibles were large folios; but in 1557 the Reformers, who had been driven out by Queen Mary, published a duodecimo edition at Geneva, and this, from its handy size, obtained the widest circulation. In opposition to these various versions learned adherents of the Catholic faith produced a new translation from the Vulgate. The

New Testament was published at Rheims in 1582, and the Old at Douay in 1609. Whatever were the merits of these various versions, the work of Tyndale remained the model, and to him must be awarded the highest honor among Bible translators. Nothing has done more to establish the English character than the free circulation of the Bible.

In the reign of Edward VI, when it was determined to have the Church service entirely in English, Cranmer edited the *Book of Common Prayer* (1552). It was formed chiefly from the Latin prayers which had been used in the Church for centuries. Its style is more marked with Latin derivatives than the Bible. It also has had marked influence on the development of English.

Roger Ascham (1515-1568) was a promoter of sound learning, and numbered among his pupils Queen Elizabeth and Lady Jane Grey, both good Greek scholars. His first publication was *Toxophilus,* which advocated the practice of archery, then falling into disuse from the improvement in firearms. Later came his *Scholemaster,* an excellent old-fashioned treatise on education, still highly prized for many judicious suggestions.

Elizabethan Literature. — The long reign of Queen Elizabeth, from 1559 to 1603, is justly celebrated for its lofty spirit of nationality, which was as marked in literature as in all other manifestations of popular tendency. Philip II of Spain had put himself forward as the champion of Catholicism, and had married Queen Mary in the vain hope of redeeming England for the Roman Church. The accession of Elizabeth was hailed by the people, and her prudent conduct in difficult circumstances, as well as her marked courage, secured her in their affections. To the last she remained the Virgin Queen, though she played with many lovers and favorites. Poets vied with each other in chanting her praises.

In the beginning of her reign there were several translations from Homer, Ovid and Vergil, which helped to make ancient mythology familiar. There was also a host of minor poets who poured forth in abundance songs and sonnets, fables and elegics, and all sorts of love poems. There were histories of various kinds, especially of England, also romantic tales and ballads, stories of voyagers to distant lands. Sir Thomas Wyatt and the young Earl of Surrey introduced the sonnet into English and made translations of Petrarch. Surrey was the first to use blank verse, which soon became the recognized metre for serious dramatic and epic poetry. Sir John Harrington translated Ariosto's *Orlando,* and Fairfax did the same for Tasso's *Jerusalem Delivered.*

Lyly's Euphues.—One of the most remarkable works of this period was John Lyly's *Euphues, the Anatomie of Wit* (1579), soon followed by *Euphues and his England* (1580). It was intended to teach by example the use of refined and courtly language. Euphues was a young Athenian, traveling first in Naples and afterward in England. With his adventures were mingled descriptions of the country, the court and the manners of the people. Its ornate style became fashionable, but was carried to an extreme and was ridiculed by Shakespeare.

Sir Philip Sidney (1554-1586) was the paragon of English chivalry, and esteemed by Elizabeth "as one of the jewels of her crown." His writings were circulated among his noble friends, but not published till after his untimely death. His *Defence of Poesie* was the first piece of criticism in the language. His romance called *The Countess of Pembroke's Arcadia* is an elaborate pastoral which long remained popular, but is now thought tedious. It is interspersed with some charming lyrics. Besides these, Sidney wrote a string of sonnets called *Astrophel and Stella.* All his productions are in the Italian style.

Edmund Spenser. — The greatest poet of this poetical period was Edmund Spenser (1553-1599). Born in London and educated at Cambridge, he won the friendship of Sidney and was patronized by Sidney's uncle, the Earl of Leicester. His *Shepherd's Calendar* (1579) consisted of twelve eclogues, one for each month. In it Colin Clout represents the poet himself, who, with his fellow-shepherds, discusses religious polemics as well as love. The greatest of his works is the *Faery Queene,* the most remarkable poetical allegory in the world. For it he invented a new stanza, which justly bears his name and has been adopted by many succeeding poets. It is founded on the Italian eight-line rhymed stanza, but to this Spenser added a concluding long line, which gives a surpassing charm to the verse. While Spenser's diction is rich and abundant, he showed unwise reverence for his master, Chaucer, by introducing many archaic and obsolete words, but he had none of Chaucer's wit and humor. The story is full of gallantry and chivalry, well adapted to the court of the Virgin Queen. Indeed, Elizabeth herself was grandly portrayed in the poem under the name Gloriana. Prince Arthur is the hero, who, having become enamored of a vision of the Faery Queen, goes forth to seek her in Faery Land. The Queen keeps her annual feast twelve days, on each of which a chosen knight has an adventure typifying a moral virtue. The first is that of the Red Cross Knight, expressing Holiness; the second, Sir Guyon, or Temperance; the third, Britomartis, a lady knight, representing Chastity. This comprised the first part, which was published in 1590. Nothing could have better captivated Elizabeth and her court than this blending of chivalry and religion. Historical personages could also be readily discerned. Besides Gloriana there is a distressed knight representing Henry IV of France; Envy seems to indicate Mary, Queen of Scots; the grim Giant is Philip II of Spain; the Red Cross Knight stands for the Church of England; Duessa is a satirical personification of the Roman Church; Una represents true religion.

The *Faery Queene* was written in the south of Ireland, where Spenser had obtained from the crown a large share of a forfeited estate on the condition of living on it. For the first part of his poem the queen granted him a pension of £60. He then returned to Ireland to continue his allegory. Many shorter poems, however, were published before the next installment appeared. Among these were the beautiful *Epithalamion,* describing his courtship and marriage, and the *Elegy on Astrophel* — that is, Sir Philip Sidney. In 1596 the continuation of the *Faery Queene* was ready. It contained the legend of Cambel and Triamond, or Friendship; Artegal, or Justice; and Sir Calidore, or Courtesy, who was in real life Sidney. As before, history was mingled with poetry and allegory. The poem still exhibits ardent love of England, hatred of Spain, devotion to Elizabeth. Except a few fragments, this was all that was accomplished of his monumental work. Spenser was driven from his home by an insurrection, the castle was burned, and an infant child perished in the flames. The broken-hearted poet died soon after reaching London. He was buried in Westminster Abbey.

Spenser is the legitimate English counterpart of the great Italian poets, Ariosto and Tasso. He equaled them in the melody of his verse and the richness of his fancy and invention. His exuberance of language often carries him too far in long descriptions, and the whole narrative is prolonged till it wearies the reader. But the main fault of this otherwise splendid work is its allegorical character, which distracts the attention of the reader. When that is entirely disregarded, the true loveliness of the poet's creations is perceived and enjoyed. Even the poet himself did not adhere to the allegory so strictly after the first two cantos. Taken as a whole, the poem grandly embodies the pure spirit of the Renaissance under Elizabeth.

UNA AND THE LION.

One day, nigh weary of the irksome way,
  From her unhasty beast she did alight;
And on the grass her dainty limbs did lay
  In secret shadow, far from all men's sight;
From her fair head her fillet she undight,
And laid her stole aside; her angel's face,
  As the great eye of heaven, shinéd bright,
And made a sunshine in the shady place;
Did ever mortal eye behold such heavenly grace?

It fortunéd, out of the thickest wood
  A ramping lion rushéd suddenly,
Hunting full greedy after salvage blood.
  Soon as the royal virgin he did spy,
  With gaping mouth at her ran greedily,
To have at once devoured her tender corse;
  But to the prey when as he drew more nigh,
His bloody rage assuagéd with remorse,
And, with the sight amazed, forgot his furious force.

Instead thereof he kissed her weary feet,
  And licked her lily hands with fawning tongue,
As he her wrongéd innocence did weet.
  Oh, how can beauty master the most strong,
  And simple truth subdue avenging wrong!
Whose yielded pride and proud submission,
  Still dreading death, when she had markéd long,
Her heart 'gan melt in great compassion;
And drizzling tears did shed for pure affection.

"The lion, lord of every beast in field,"
  Quoth she, "his princely puissance doth abate,
And mighty proud to humble weak doth yield,
  Forgetful of the hungry rage which late
  Him pricked, in pity of my sad estate.
But he, my lion, and my noble lord,
  How does he find in cruel heart to hate
Her that him loved, and ever most adored
As the god of my life? Why hath he me abhorred?"

Redounding tears did choke th' end of her plaint,
  Which softly echoed from the neighbor wood;
And, sad to see her sorrowful constraint,
  The kingly beast upon her gazing stood:
  With pity calmed, down fell his angry mood.
At last, in close heart shutting up her pain,
  Arose the virgin born of heavenly brood,
And to her snowy palfrey got again,
To seek her strayéd champion if she might attain.

The lion would not leave her desolate,
  But with her went along, as a strong guard
Of her chaste person, and a faithful mate
  Of her sad troubles and misfortunes hard.
  Still when she slept he kept both watch and ward;
And when she waked he waited diligent
  With humble service to her will prepared.
From her fair eyes he took commandément,
And ever by her looks conceivéd her intent.

Dramatic Literature.—Grand and luxuriant as was its poetry, it is yet by its more wonderful drama that the golden age of Elizabeth is characterized and remembered. The drama in England began with the midsummer exhibitions of the trade guilds in the streets of the towns. These Coventry and Towneley and York plays have in recent years been recovered and studied diligently. The mysteries and miracle plays were dramatic exhibitions of Scripture stories or of legends of saints. Then came moralities, in which virtues and vices were personified. In the religious struggle at the beginning of the Reformation such plays were used to support both the Catholic and the Protestant side. Real men began to be shown under the veil of allegorical characters. The personal element soon drove out the abstractions. The people found a new delight in vivid representations of historical scenes, ancient and modern. In connection with the moralities there had sometimes been interludes—short humorous scenes intended for the amusement of the common people. These were enlarged by John Heywood for representation at the court of Henry VIII.

Rise of the Regular Drama.—The first regular comedy was *Ralph Roister Doister,* written by Nicholas Udall, which was first acted about 1550, but not printed till 1562. It is divided into regular acts and scenes, and gives a picture of London life. The first regular tragedy was *Gorboduc, or Ferrex and Porrex,* written by Sackville and Norton, and acted in 1562. The story was taken from early British legend, but the piece was too solemn to suit the taste of the audience. Soon students from the universities began to offer dramas from classical story, some directly translated, others imitated. Then Italian stories were taken, one of the first being *Romeo and Juliet,* afterward reconstructed by Shakespeare. But the people seemed to give the preference to the rousing patriotic chronicle plays, such as *The Famous Victories of Henry V.*

The Theatres.—In 1574 the Earl of Leicester's servants received a patent to act plays in any town in England, and two years later they erected the first playhouse at Blackfriars. Two others soon followed on the outskirts of London. The Globe Theatre, built for Shakespeare's company in 1599, was circular within, but had six sides without. It was modeled after the courtyard of an inn, being open to the weather except above the stage; the people stood in the yard or pit, while the nobles sat in boxes or even on the stage, which was strewn with rushes. There was no scenery, but a board hung at the top stated the place of action. Boys acted the female parts. The performance was in the afternoon.

Marlowe.—The earliest plays were written in prose, or more frequently in rhyme, but Christopher Marlowe (1564-1593), in his *Tamburlaine the Great* (1587) introduced blank verse, which became the standard. The play itself, in spite of its bombast, is noble in spirit and has many passages of pure poetry. Another of his plays was *The Tragical History of Doctor Faustus,* which first set forth the dreadful results of mastery over nature obtained by compact with Lucifer. Faustus agrees, in return for twenty years of enjoyment of supernatural power, to yield, then, body and soul, to the Prince of Darkness. It ends with an appalling scene, in which Faustus meets his doom amid the crash of a thunder storm. Still other notable dramas of this short-lived genius are *Edward the Second* and *The Jew of Malta.* Kit Marlowe was himself a reckless atheist, and perished in a tavern brawl. Among his rival dramatists were George Peele and Robert Greene, men of the same riotous character, whose writings are studied now for the light which they shed on the beginning of Shakespeare's career. Their dramas are always exaggerated in the treatment and expression of human beings.

Shakespeare. — The fame of William Shakespeare (1564-1616) has steadily grown until he is now recognized as the greatest dramatist of the world. His birthplace at Stratford-on-Avon has become a shrine for pilgrims. His father was a respectable citizen, but afterward fell into misfortune, from which his son generously relieved him. Shakespeare learned some Latin at the grammar school of Stratford, but shows no real evidence of knowledge of Greek. At the early age of nineteen he married Anne Hathaway, seven years older than himself. The hasty marriage seems to have been unhappy. Three years later he went to London, where some of his fellow-townsmen were prospering. Shakespeare joined them and soon became an actor and playwright. In 1592 he published the luscious poem *Venus and Adonis,* which he called "the first heir of his invention." It won for him the favor of Lord Southampton and other men of influence. His next poem was *The Rape of Lucrece,* which, like the other, passed through several editions.

His dramatic work began with touching up old plays, among them being the bloody *Titus Andronicus,* the revolting *Pericles* and *The First Part of Henry VI.* But the first of his original plays was *Love's Labour's Lost,* in which he satirizes the affected style of *Euphues.* In the *Comedy of Errors* he adapted a Latin play by Plautus, making it rather a farce. The enchanting *Midsummer*

Night's Dream is a singular medley of ancient legend and mediæval fairyland with the life of English clowns. In *The Two Gentlemen of Verona* Italian life is finely depicted. *All's Well that Ends Well* is thought by good critics to be a revised version of a play, *Love's Labour's Won,* given in some lists of his work. These love-plays were followed by the great series of historical plays which popular taste seemed then to crave. Shakespeare was undoubtedly a prudent manager, and trimmed his sails to catch the breeze. The first written of these histories was *Richard II,* in 1593. Then came *Richard III,* which still holds the stage, though somewhat modified by later playwrights. He also recast the *Second* and *Third Parts of Henry VI,* written by some unknown author. Then, going back in history, he produced *King John* as an introduction to this series.

Shakespeare had now attained perfect mastery of his art in all its details. This is proved by his *Merchant of Venice,* in which tragedy and comedy are harmoniously blended. In the *Taming of the Shrew* he gives pure comedy of the most entertaining kind. Again turning to history, he produced the first and second parts of *Henry IV,* in which Falstaff and his boon companions furnish admirable comedy. Queen Elizabeth is said to have been so delighted with the witty fat knight that she requested the author to depict Falstaff in love. The result is seen in *The Merry Wives of Windsor.* Another stirring historical play is *Henry V,* which celebrates in thrilling scenes the glory of England. A new series of love-comedies followed—the witty *Much Ado about Nothing;* the romantic *As You Like It,* in which the playful Rosalind is contrasted with the melancholy Jaques; the merry *Twelfth Night. All's Well that Ends Well* seems to belong to the same period, in which his powers were mature and his disposition philosophic. Shakespeare was now wealthy, associated with noblemen, and enjoyed the favor of the queen.

About 1600 a change seems to have come over his mind and character. His noble friends fell into the displeasure of the queen; Southampton was sent to the Tower, Essex perished on the scaffold. The *Sonnets* of Shakespeare are his most mysterious writings. Though not published till 1609, many of them seem to have been written ten years earlier. In them appear indications that he had been betrayed by a trusted friend. There are also expressions of disgust for his profession.

In the eight years from 1601 appeared several of Shakespeare's most powerful tragedies. *Julius Cæsar,* that remarkable dramatization of Plutarch's narrative, led the way. Then came *Hamlet,* which has taxed the talents of critics and commentators for adequate interpretation. It seems to manifest the inadequacy of philosophy in dealing with the miseries of life. Hamlet, the dreamer, unnerved by his father's apparition, shocked by the discovery of that father's murder and of his mother's guilty complicity, drives his beloved to insanity and suicide, wantonly slays her father, and falls by an accidental miscarriage of his petty scheme for revenge and reversal of evil. Yet all the while he can discourse most ingeniously and profoundly of the mysteries of life and death. Shakespeare's next play was the grim, depressing *Measure for Measure* — tragic in tone throughout. Then came three tragedies—*Othello,* in which a noble nature is driven to blind jealousy and desperate crime by a heartless, malicious villain; *Macbeth,* in which an ambitious woman urges on a weaker nature to win lordship by murder and then become the victim of avenging conscience; *Lear,* in which fatherly affection by its own weakness proves its own undoing. Such a series of heartrending tragedies surely betokens severe stress on the spirit of the author. Next he is found turning to Greece and Rome for themes to relieve his gall of bitterness. *Troilus and Cressida,* following a mediæval perversion of ancient story, is a tragedy of pessimism, in which the sweetest joys of life are turned to bitterness. *Antony and Cleopatra,* true to history, shows the Roman warrior a foolish captive of a wanton's beauty. *Coriolanus* exhibits the proud, unbending aristocrat overcome by the despicable, fickle mob. *Timon of Athens* exhibits the extreme of misanthropy. Thus the records of history and romance seem to have been ransacked for themes exposing the darker side of human nature in all its hideous complications.

Yet from this period of gloom the mighty dramatist seems to have emerged into a serener, brighter atmosphere. In his last works can be traced a nature which has experienced wrong and grief, yet has surmounted them and reached a happy haven. In *A Winter's Tale* there is a reminiscence of early life amid country scenes. *Cymbeline,* a strange, romantic story relating to the times of Roman occupation of Britain, breathes a spirit of resignation after vain struggles. *The Tempest* is a wronged exile's cheerful review of the world, once forsaken as utterly evil, now acknowledged to be an abode of happiness for loving creatures. Tricksy Ariel hovers above, and even bestial Caliban seems redeemed. This would form, indeed, a fitting conclusion to Shakespeare's work. Yet there is still a final contribution to history, unless those critics are right who deny his authorship of *Henry VIII.*

But internal evidence rather favors his claim to the portrayal of the stately Katharine, the proud Wolsey and the relentless King. A few other plays have also been attributed in part to the great dramatist.

Shakespeare never lost his affection for his native place. After a career of unexampled success in London he returned to Stratford crowned with wealth and honors. He had years before purchased a dwelling there in which his family were installed. The last years of his life were spent in cordial intercourse with his fellow-townsmen, and he was followed to the grave with the respect of the whole community. He had been called by his friends the gentle Shakespeare, by fellow-poets the mellifluous Shakespeare, and more than two centuries after his death Coleridge called him the myriad-minded Shakespeare.

There has been abundant complaint that we know so little of the details of his life; yet, in fact, we know as much as we do of any of his rival dramatists. There has sprung up a strange delusion that plays so transcendent in genius could not be written by one of such humble origin; that, in fact, they must have been written by his learned contemporary, Lord Bacon, sometimes called the father of modern science. But why this great man, who did not neglect to affix his name to so many works, English as well as Latin, should attempt to bury his authorship of these plays in an absurd cryptogram is a puzzle beyond understanding.

Let us rejoice that this author was able to hold the mirror up to nature and to depict so accurately and vividly such a variety of men and women worthy to be known and admired. His exuberant imagination rose even beyond the limits of human nature, and enabled him to summon spirits and fairies from the ambient air. In creative power, impassioned conception and execution, in fullness of expression and in strong romantic feeling he remains the greatest literary artist of the modern world.

Prospero's Valediction, which is given below, is taken from the last act of *The Tempest*. It is regarded by many critics as Shakespeare's farewell address at the conclusion of his dramatic labors.

ROMEO AND JULIET.

Romeo.—But soft, what light through yonder window breaks?
It is the east, and Juliet is the sun!—
Arise, fair sun, and kill the envious moon,
Who is already sick and pale with grief,
That thou her maid art far more fair than she:
Be not her maid, since she is envious;
Her vestal livery is but sick and green,
And none but fools do wear it; cast it off.
It is my lady, O, it is my love!
O that she knew she were!
She speaks, yet she says nothing: what of that?
Her eye discourses; I will answer it.
I am too bold, 'tis not to me she speaks.
Two of the fairest stars in all the heaven,
Having some business, do entreat her eyes
To twinkle in their spheres till they return.
What if her eyes were there, they in her head?
The brightness of her cheek would shame those stars,
As daylight doth a lamp; her eyes in heaven
Would through the airy region stream so bright
That birds would sing, and think it were not night.
See how she leans her cheek upon her hand!
O, that I were a glove upon that hand,
That I might touch her cheek.
Juliet.—(Above)—Ay me!
Rom.— She speaks:
O, speak again, bright angel! for thou art
As glorious to this night, being o'er my head,
As is a winged messenger of heaven
Unto the white-upturned wondering eyes
Of mortals that fall back to gaze on him
When he bestrides the lazy-pacing clouds
And sails upon the bosom of the air.
Jul.—O Romeo, Romeo! wherefore art thou Romeo?
Deny thy father and refuse thy name:
Or, if they wilt not, be but sworn my love,
And I'll no longer be a Capulet.
Rom.—(Aside.) Shall I hear more, or shall I speak at this?
Jul.—'Tis but thy name that is my enemy;
Thou art thyself, though not a Montague.
What's Montague? it is nor hand, nor foot,
Nor arm, nor face, nor any other part
Belonging to a man. O, be some other name!
What's in a name? that which we call a rose
By any other name would smell as sweet;
So Romeo would, were he not Romeo call'd,
Retain that dear perfection which he owes
Without that title. Romeo, doff thy name,
And for that name which is no part of thee
Take all myself.
Rom.— I take thee at thy word:
Call me but love, and I'll be new-baptized;
Henceforth I never will be Romeo.
Jul.—What man art thou that thus bescreen'd in night
So stumblest on my counsel?
Rom.— By a name
I know not how to tell thee who I am:
My name, dear saint, is hateful to myself,
Because it is an enemy to thee;
Had I it written I would tear the word.
Jul.—My ears have not yet drunk a hundred words
Of that dear tongue's utterance, yet I know the sound:
Art thou not Romeo, and a Montague?
Rom.—Neither, fair saint, if either thee dislike.
Jul.—How camest thou hither, tell me, and wherefore?
The orchard walls are high and hard to climb,
And the place death, considering who thou art,
If any of my kinsmen find thee here.

Rom.—With love's light wings did I o'erperch these walls
For stony limits cannot hold love out,
And what love can do that dares love attempt;
Therefore thy kinsmen are no let to me.
Jul.—If they do see thee, they will murder thee.
Rom.—Alack, there lies more peril in thine eye
Than twenty of their swords: look thou but sweet,
And I am proof against their enmity.
Jul.—I would not for the world they saw thee here.
Rom.—I have night's cloak to hide me from their sight;
And but thou love me, let them find me here:
My life were better ended by their hate,
Than death prorogued, wanting of thy love.

PROSPERO'S VALEDICTION.

(From *The Tempest*, Act V, Scene I.)

Prospero.— Go release them, Ariel:
My charms I'll break, their senses I'll restore,
And they shall be themselves.
Ariel.— I'll fetch them, sir. (Exit.)
Pros.—Ye elves of hills, brooks, standing lakes and groves,
And ye that on the sands with printless foot
Do chase the ebbing Neptune, and do fly him
When he comes back; you demi-puppets that
By moonshine do the green-sour ringlets make,
Whereof the ewe not bites, and you whose pastime
Is to make midnight mushrooms, that rejoice
To hear the solemn curfew; by whose aid,
Weak masters though ye be, I have bedimm'd
The noontide sun, call'd forth the mutinous winds,
And 'twixt the green sea and the azured vault,
Set roaring war; to the dread rattling thunder
Have I given fire, and rifted Jove's stout oak
With his own bolt; the strong-based promontory.
Have I made shake, and by the spurs pluck'd up
The pine and cedar; graves at my command
Have waked their sleepers, opéd, and let 'em forth
By my so potent act. But this rough magic
I here abjure, and when I have required
Some heavenly music, which even now I do,
To work mine end upon their senses that
This airy charm is for, I'll break my staff,
Bury it certain fathoms in the earth,
And deeper than did ever plummet sound
I'll drown my book. . . . .
Our revels now are ended. These our actors,
As I foretold you, were all spirits, and
Are melted into air, into thin air:
And, like the baseless fabric of this vision,
The cloud-capp'd towers, the gorgeous palaces,
The solemn temples, the great globe itself,
Yea, all which it inherits, shall dissolve.
And, like this unsubstantial pageant faded,
Leave not a rack behind. We are such stuff
As dreams are made of, and our little life
Is rounded with a sleep.

Ben Jonson.—The greatest of Shakespeare's dramatic contemporaries was Ben Jonson (1573-1637). Though a clergyman's son, he was in early life compelled to work as a bricklayer, and then became a soldier. Yet at the age of twenty he was married and went on the stage. Having quarreled with another performer, he fought a duel and was severely wounded, but killed his opponent. After a short imprisonment he was released without trial. He then commenced writing for the theatre, producing in 1598 *Every Man in His Humour.* Jonson's comedy differed from Shakespeare's in being an attempt to reproduce the actual manners of his countrymen. The public approved and Queen Elizabeth patronized him. In the next year he produced *Every Man Out of His Humour.* By *humour* Jonson meant a special bias by which the actions of men are distracted. In *Cynthia's Revels* he aimed to satirize the courtiers, and in reply to their opposition he wrote *The Poetaster,* attacking Dekker and others who took sides against him. Dekker then parodied Jonson's play in the *Satiro-Mastix,* calling him "The Staring Leviathan." Jonson then turned to tragedy, and his *Sejanus* was a careful transcript from ancient Roman life. Jonson was a truly learned man, though it is difficult to see how he had acquired his knowledge of Greek and Latin. In the reign of James I he produced three fine comedies—*Volpone the Fox, The Silent Woman* and *The Alchemist* (1610)—the first being the best. *Catiline* was another Roman tragedy, carefully wrought. In 1611 Jonson was made Poet Laureate. He has been justly pronounced "a robust, surly and observing dramatist."

Religious Literature.—The social revolution which is known as the Reformation was not confined to religion or ecclesiastical affairs. It affected every department of thought and public activity. It extended to all classes and found expression in many modes. Yet, of course, those whose lives were devoted to religious pursuits often used pen and press as well as speech in behalf of their creeds and theological views. Not only was much written against the teaching and practice of the Roman Church, but in the English Church, after its separation, there was controversy between two great parties, one content with definitely nationalizing the ancient faith, the other seeking a radical change in doctrine and practice such as had been declared by Luther and still more by Calvin. The contest among the partisans was carried on chiefly by pamphlets, but there were some larger treatises of permanent literary value. The greatest of these is due to the genius of Richard Hooker (1553-1600). Distinguished for eloquence and learning at Oxford, he was appointed Master of the Temple in London. His sermons were vigorous arguments for the Anglican Church. When he retired to a country parish he devoted himself to a systematic statement of his views of Church government. The great work thus composed is called *A Treatise on the Laws of Ecclesiastical Polity.* It is not merely controversial, but bases its arguments on the fundamental truths on which rest all laws, political as well as ecclesiastical. By clear and vigorous style, often rising to sublime eloquence, it gave new dignity to English prose. It is one of the noblest monuments of the reign of Elizabeth.

It may be noted here that the *Book of Common Prayer* is a literary memorial of the brief reign of Edward VI. It is a modified translation of the Latin ritual which had for centuries been used by the Christian Church. Its style, somewhat uneven, exhibits that blending of Latin and native English which has characterized the Anglican Church and its branches.

CHAPTER IV.

Literature from Elizabeth to the Restoration of Charles II.

A. D. 1603—1660.

The Accession of the Stuarts.—With the death of Elizabeth in 1603 the House of Tudor came to an end. The crown devolved on James VI of Scotland, son of Mary, Queen of Scots, whom Elizabeth had beheaded. The new king was glad to escape from Scotland, where he had been brought up among critical Presbyterians and yet had engaged in intrigues with Catholic Spain. He found the English bishops and nobles eager to welcome him and anxious to please him. Thus he became James I of England. He was a learned pedant, versed in theology and statecraft, yet vain and foolish. When the two parties in the Church of England appealed to him for settlement of disputed points, he called the Hampton Court Conference, in which Puritans and Anglicans argued against each other. The king refused any relaxation for the Puritans.

King James's Bible.—The most important result of this conference was the ordering of a new translation of the Bible by a large committee of scholarly divines. The outcome was the publication in 1611 of the Bible which has since been called the Authorized Version. It differs but little from the previous versions, which it soon superseded. Criticisms have been passed on it favorable and adverse. Even at its first appearance it was pronounced by competent judges too archaic and too Hebraic; but the vast majority of critics of a later day have agreed with the opinion of Bishop Middleton, who said: "The style is simple, it is harmonious, it is energetic, and, which is of no small importance, use has made it familiar and time has rendered it sacred." One of the finest tributes to its excellence was made by Cardinal John Henry Newman. People of all denominations became so wedded to its phraseology that, though occasional attempts were made to improve it, there was none undertaken on a large or promising plan until 1872, when a Revised Version was prepared by an equally learned body composed of British and American Biblical scholars. The results of these labors were published in 1881 and 1887, but the fond anticipations of its success have not been largely realized.

James's Relation to Literature.—The accession of James I checked the strong national feeling which had prevailed throughout Elizabeth's reign. The king showed friendship for Spain, which the English people had learned to hate. He even sought a Spanish princess as his son's wife. But though James was lacking in tact and genuine statesmanship, he possessed much learning and was ever ready to express his opinions. He wrote poetry, as well as prose. Before he came to the English throne he had issued *Essays of a Prince in the Divine Art of Poetry* (1584), *Demonology* (1597), *Basilicon Doron* (1599). His most noted work afterward was *A Counterblast to Tobacco* (1616), a vain attempt to blow away the smoke. He wished to pose as a British Solomon, but only proved himself "the wisest fool in Christendom."

Throughout the Stuart reigns king and people were moving in different directions in political and religious matters. The strong notions of the divine right of kings which James transmitted to his family brought his son to the scaffold and drove his grandson from the throne.

Literature in the reigns of James and Charles I showed a gradual decay of power. Yet much of the Elizabethan spirit lingered, and the change was not visible at once. Shakespeare and other dramatists continued to issue noble plays, and many valuable works appeared until the energies of the people were wasted in internal dissensions. The growing discontent of earnest spirits, however, led to the first attempts to colonize America, where a new England was planted.

Sir Walter Raleigh.—The romantic career of Sir Walter Raleigh (1552-1618) belongs rather to the political than to the literary history of England. He was a favorite courtier of Queen Elizabeth, a daring navigator and a brave soldier; but when the pedantic James I came to the throne of England, Raleigh, who was implicated in a plot in favor of Lady Arabella Stuart, lost his good fortune. Charged with treason, he was imprisoned in the Tower for fourteen years. Here he wrote his picturesque *History of the World,* more distinguished for literary style than accuracy in facts or theory. At last he was released and allowed to go in search of *Eldorado,* in South America. The expedition was unfortunate. The Spanish government complained of it, and Raleigh on his return was arrested and beheaded.

Francis Bacon.—No man more impressed upon his contemporaries a feeling of his intellectual greatness than Francis Bacon, Viscount St. Albans (1561-1626). This lofty reputation has been sustained by the voice of succeeding generations. Yet some critics have questioned whether it is really deserved. Although he is said to have inaugurated modern science, he actually held the old views which contemporary scientists, as Kepler and Galileo, had disproved. Induction, which he is said to have introduced as the basis of natural philosophy, had been used long before. He inculcated experiment as the sure basis of philosophy, and laid down excellent maxims for the proper conduct of them; yet the numerous experiments which he advised were futile. His aim was to bring philosophy out of the cloisters and make it known to all men. To this end he used familiar terms and thus seemed to render it intelligible. His best work belongs to literature rather than to science. His *Essays* or *Counsels Civil and Moral* (1597) were the first writings of the kind, and are still the most read. They are short, pithy and sententious. Next in value comes *The Advancement of Learning*, but his scientific works are utterly obsolete. They were mostly written in Latin, but have been carefully translated into English. When his *Novum Organum* appeared in 1620, King James said wittily, but rather profanely, that it was like the peace of God, "because it passeth all understanding." Its aim was to supersede the old method of using reason and obtaining truth by syllogisms as prescribed by Aristotle's *Organon,* and introducing the better method of interpreting nature by a higher logic. The *Novum Organum* was but one of the six parts of the entire work called *Magna Instauratio* (The Great Restoration).

Bacon was the son of one of Elizabeth's state officials, and was carefully trained for high positions. Dissatisfied with the barren studies pursued at Oxford, he went to France in a minor diplomatic position. His first literary work was *Of the State of Europe.* On his father's death in 1579 he returned to England and studied law. He won the favor of Essex, then the Queen's favorite, but later, when Essex was charged with treason, Bacon was the prosecutor. He has been charged with ingratitude, but careful investigators think his course was justifiable. He entered Parliament and steadily sought preferment. At the coronation of James I in 1603 Bacon was knighted, afterward made Lord Keeper, with the title Baron Verulam, and finally Lord Chancellor and Viscount St. Albans. While discharging the duties of his various offices with diligence and energy, he was always subservient to his sovereign. But the administration of James I was weak and inefficient, and Bacon a victim of the odium it incurred. In 1621 he was convicted of corruption in office and condemned to severe penalties. These, however, were remitted, and a few years later a pension was bestowed on him. This he enjoyed but two years.

Bacon's profound confidence in his own intellectual power and the importance of the work he had accomplished is shown in his testament: "I bequeath my labors to posterity; my name and memory to foreign nations and to my own country after some time is past." Many of his countrymen have given their judgment. Izaak Walton pronounced Bacon "the great secretary of nature and all learning." Pope's summary of his character is more familiar: "The wisest, brightest, meanest of mankind." Great as were his merits and his faults, none of these superlatives seems deserved. Burke and Macaulay have paid noble tributes to Bacon's memory.

OF STUDIES.

Studies serve for delight, for ornament, and for ability. Their chief use for delight is in privateness and retiring; for ornament, is in discourse; and for ability, is in the judgment and disposition of business. For expert men cannot execute, and perhaps judge of particulars one by one; but the general counsels, and the plots and marshalling of affairs, come best from those that are learned. To spend too much time in studies is sloth; to use them too much for ornament is affectation; to make judgment wholly by their rule is the humor of a scholar. They perfect nature, and are perfected by experience; for natural abilities are like natural plants, that need pruning by study; and studies themselves do give forth directions too much at large, except they be bounded by experience. Crafty men contemn studies, simple men admire them, and wise men use them; for they teach not their own use; but that is a wisdom, without them and above them, won by observation. Read not to contradict and confute, nor to believe and take for granted, nor to find talk and discourse, but to weigh and consider.

Some books are to be tasted, others to be swallowed, and some few to be chewed and digested.

> That is, some books are to be read only in parts; others to be read, but not curiously; and some few to be read wholly, and with diligence and attention. Reading maketh a full man, conference a ready man, and writing an exact man. Therefore if a man write little, he had need have a great memory; if he confer little, he had need have a present wit; and if he read little, he need have much cunning, to seem to know what he doth not. Histories make men wise; poets, witty; the mathematicians, subtile; natural philosophy, deep; moral, grave. Studies become habits: nay there is no stand or impediment in the wit, but may be wrought out by fit studies; like as diseases of the body may have appropriate exercises: bowling is good for the stone and reins; shooting for the lungs and breast; gentle walking for the stomach; riding for the head—and so on. So if a man's wit be wandering, let him study the mathematics; for in demonstrations, be his wit called away never so little, be must begin again. If his wit be not apt to distinguish or find difference, let him study the schoolmen; for they are "splitters of cummin-seeds." If he be not apt to beat over matters, and to call up one thing to prove and illustrate another, let him study the lawyer's cases. So every defect of the mind may have a special receipt.

Dramatic Literature. — The great dramatists who are the literary glory of Elizabeth's reign continued their work under her successor. Shakespeare retired in 1613 and died three years later, but his collected plays were not published till 1623, when the celebrated first folio was issued by his surviving partners, who owned the stage copies. Ben Jonson's last play, *The New Inn,* was exhibited in 1630, when paralysis had impaired his powers. But other dramatists of inferior genius arose to enliven the stage and imitate their great predecessors. The Puritans clamored against the theatre, while the playwrights, seeking to win popularity by catering to gross tastes, sank from bad to worse.

Beaumont and Fletcher.—The unique partnership of Francis Beaumont (1584-1615) and John Fletcher (1579-1625) is notable in the history of literature. These two poets, the former the son of a knight, the latter the son of a bishop, lived together near the theatre for ten years, and worked in such harmony that critics are baffled in trying to assign to each his proper share in their joint production. Evidently inspired by Shakespeare's influence, they never equaled their master, yet Dryden says that in his day their plays were more frequently given, because they imitated the conversation of gentlemen better. They exhibit the confidence and buoyancy of youth with the refinement of gentlemen. Licentiousness is their greatest blemish. Their collected dramas—passionate, romantic and comic—were published in 1647. Among these is *The Two Noble Kinsmen,* which in its first edition bore on the title page Shakespeare's name joined with Fletcher's. *Philaster* was the first of Beaumont and Fletcher's plays to win favor. In it Euphrasia, like Shakespeare's Viola, assumes a boy's dress that she may attend her beloved as a page. There are interesting scenes, but Philaster's jealousy is improbable. *The Maid's Tragedy* is a powerful but licentious play. Among their comedies are *The Woman-hater* and *The Knight of the Burning Pestle,* the latter ridiculing the fondness of London citizens for chivalric shows. Their characters are deficient in variety, but their knowledge of stage effect, their fertility of invention and the briskness of their dialogue give novelty and interest to their scenes. Though Beaumont was the younger, death snatched him away when barely thirty years old. Fletcher continued his labor for the stage, producing three tragedies and nine comedies. His comic talent was certainly superior to his tragic. His exquisite pastoral, *The Faithful Shepherdess,* supplied Milton with the design and much of the imagery of his *Comus.*

Thomas Dekker is noted in literary history for his quarrel with Ben Jonson, which has already been mentioned. He wrote some twenty plays, of which *Fortunatus, or the Wishing Cap,* and *The Honest Whore* are the best. His plays contain many fine passages, one of which, on Patience, deserves quotation:

Patience! why, 'tis the soul of peace:
Of all the virtues, 'tis the nearest heaven.
It makes men look like gods. The best of men
That e'er wore earth about him was a sufferer,
A soft, meek, patient, humble, tranquil spirit,
The first true gentleman that ever breath'd.

Dekker's own life was spent in poverty, sometimes in prison for debt, perhaps due to irregular habits. His own experience may have prompted the line—

We ne'er are angels till our passions die.

John Webster was a close associate with Dekker, and they wrote some plays in partnership. A contemporary record notes him as a merchant tailor, but he was none the less a powerful tragic writer. His two greatest productions are *The Duchess of Malfi* and *The White Devil, or Vittoria Corombona.* Yet the latter was not successful on the stage, probably owing to the hateful character of the principal personage. The former turns on the mortal offense which the duchess gives her proud twin brother, Duke Ferdinand, by her generous infatuation for her steward, Antonio. She is seized and thrown into prison, where she is subjected to many cruelties, in the expectation of driving her to insanity. Finally she is strangled. Throughout the whole the duchess conducts herself with noble dignity, both in declaring her affection for her dependent and in submitting to the terrible outrages inflicted on her.

John Ford (1586-1639) was another powerful dramatist. By profession a barrister, he contributed only occasionally to the stage. He was proud and gloomy, and found vent for his disposition in depicting terrible excess of passion, love, jealousy and revenge. His heroines are not soft and tender, but firm and resolute as the men they love. In *The Broken Heart* Queen Calantha endures a long series of appalling misfortunes without betraying her inward misery until, after she has arranged the affairs of her kingdom, she falls dead. Others of his tragedies are *Lover's Melancholy* and *Love's Sacrifice.* His *Perkin Warbeck* is a spirited historical drama.

Philip Massinger. — The greatest dramatist among the successors of Shakespeare was, perhaps, Philip Massinger (1584-1639), yet he lived in obscurity and died in want. He was constant in adherence to the Roman Catholic faith. Among his tragedies are *The Virgin Martyr* (1620) and *The Fatal Dowry* (1620). But he is best known by his comedies, *A New Way to Pay Old Debts* (1625) and *The City Madam* (1632). The former has kept possession of the stage, and many eminent actors have appeared in it as Sir Giles Overreach. In the latter the luxuries and vice of city life arouse forcible invective. The low characters of his plays are too depraved, and the dialogue is often coarse and indelicate. But his pictures of suffering virtue, its struggles and trials, are suited to touch the heart and gratify the taste. The tragedies of Massinger have a lofty pride and dignified seriousness which strongly impress the imagination. We quote the scene in which Sir Giles Overreach announces his daughter's portion to his intended son-in-law:

SIR GILES OVERREACH.

Overreach.—I come not to make offer with my daughter
A certain portion; that were poor and trivial:
In one word, I pronounce all that is mine,
In lands or leases, ready coin or goods,
With her, my lord, comes to you; nor shall you have
One motive to induce you to believe
I live too long, since every year I'll add
Something unto the heap, which shall be yours too.
Lovel.—You are a right kind father.
Over.—You shall have reason
To think me such. How do you like this seat?
It is well wooded and well watered, the acres
Fertile and rich: would it not serve for change,
To entertain your friends in a summer's progress?
What thinks my noble lord?
Lov.—'Tis a wholesome air,
And well built pile; and she that's mistress of it,
Worthy the large revenue.
Over.—She the mistress!
It may be so for a time; but let my lord
Say only that he but like it, and would have it;
I say, ere long 'tis his.
Lov.—Impossible.
Over.—You do conclude too fast; not knowing me,
Nor the engines that I work by. 'Tis not alone
The Lady Allworth's lands, for those once Wellborn's
(As by her dotage on him I know they will be)
Shall soon be mine; but point out any man's
In all the shire, and say they lie convenient
And useful for your lordship, and once more,
I say aloud, they are yours.
Lov.—I dare not own
What's by unjust and cruel means extorted:
My fame and credit are more dear to me
Than so to expose 'em to be censured by
The public voice.
Over.—You run, my lord, no hazard:
Your reputation shall stand as fair
In all good men's opinions as now:
Nor can my actions, though condemned for ill,
Cast any foul aspersion upon yours.
For though I do contemn report myself
As a mere sound, I still will be so tender
Of what concerns you in all points of honour,
That the immaculate whiteness of your fame,
Nor your unquestioned integrity,
Shall e'er be sullied with one taint or spot
That may take from your innocence and candour.
All my ambition is to have my daughter
Right honourable; which my lord can make her:
And might I live to dance upon my knee
A young Lord Lovel, born by her unto you,
I write nil ultra to my proudest hopes.
As for possessions and annual rents,
Equivalent to maintain you in the port
Your noble birth and present state require,
I do remove that burden from your shoulders,
And take it on mine own; for though I ruin
The country to supply your riotous waste,
The scourge of prodigals (want) shall never find you.
Lov.—Are you not frighted with the imprecations
And curses of whole families, made wretched
By your sinister practices?
Over.—Yes, as rocks are
When foamy billows split themselves against
Their flinty ribs; or as the moon is moved
When wolves, with hunger pined, howl at her brightness.
I am of a solid temper, and, like these,
Steer on a constant course: with mine own sword,
If called into the field, I can make that right
Which fearful enemies murmured at as wrong.
Now, for those other piddling complaints,
Breathed out of bitterness; as, when they call me
Extortioner, tyrant, cormorant, or intruder
On my poor neighbour's right, or grand incloser

Of what was common to my private use;
Nay, when my ears are pierced with widows' cries,
And undone orphans wash with tears my threshold,
I only think what 'tis to have my daughter
Right honourable; and 'tis a powerful charm
Makes me insensible of remorse or pity,
Or the least sting of conscience.
Lov.—I admire
The toughness of your nature.
Over.—'Tis for you,
My lord, and for my daughter, I am marble.

BEN JONSON'S TRIBUTE TO SHAKESPEARE.

To the Memory of my Beloved Master William Shakespeare, and What he hath Left us.

* * * * * * * *

Triumph, my Britain, thou hast one to show,
To whom all scenes of Europe homage owe.
He was not of an age, but for all time!
And all the Muses still were in their prime,
When, like Apollo, he came forth to warm
Our ears, or like a Mercury to charm!
Nature herself was proud of his designs,
And joyed to wear the dressing of his lines.
Which were so richly spun, and woven so fit,
As, since, she will vouchsafe no other wit.
The merry Greek, tart Aristophanes,
Neat Terence, witty Plautus, now not please;
But antiquated and deserted lie,
As they were not of Nature's family.
Yet must I not give Nature all; thy Art,
My gentle Shakspeare, must enjoy a part.
For though the poet's matter Nature be,
His Art doth give the fashion; and that he
Who casts to write a living line, must sweat
(Such as thine are) and strike the second heat
Upon the Muses' anvil, turn the same,
And himself with it, that he thinks to frame;
Or for the laurel he may gain to scorn;
For a good poet 's made, as well as born.
And such wert thou! Look, how the father's face
Lives in his issue, even so the race
Of Shakspeare's mind and manners brightly shines
In his well turnèd and true filèd lines,
In each of which he seems to shake a lance,
As brandished at the eyes of ignorance.
Sweet Swan of Avon! what a sight it were
To see thee in our waters yet appear,
And make those flights upon the banks of Thames,
That so did take Eliza and our James!
But stay, I see thee in the hemisphere
Advanced, and made a constellation there!
Shine forth, thou Star of Poets, and with rage
Or influence chide or cheer the drooping stage,
Which, since thy flight from hence, hath mourned like night,
And despairs day but for thy volume's light.

Poets.—Besides the dramatists there were some noble poets in the reign of the first Stuarts. Though their merits have been eclipsed by the brightness of Spenser and Milton, they should not be overlooked entirely.

Samuel Daniel (1562-1619) chose the hopeless task of turning history into poetry. His principal work is a *History of the Civil Wars between York and Lancaster* (1604). His verse flows on in a clear, equable stream, but lacks animation. He has been called "the well-languaged Daniel," but this commendation of his style does not atone for the tediousness of his eight books. He wrote, also, tragedies and masques, which likewise fail to interest, and epistles which are more pleasing.

Michael Drayton (1563-1631) was also a chronicle poet, and in his *Barons' Wars* and *England's Heroical Epistles* showed more animation than Daniel; but his chief work is one of a still more difficult kind, and, indeed, unique. It is, in fact, an elaborate geography in verse, and though this statement may seem to condemn it, we must admit that it possesses the elements of poetry. Its name, *Polyolbion* (Very Rich), denotes England, over whose fields the poet roams, describing its scenery with all its historical associations, stories of Robin Hood and fighting nobles being interspersed with lively personifications of hills, woods and rivers. *The Battle of Agincourt* is one of the finest war-ballads in English. The patriotic poet was indeed worthy of his stately monument in Westminster Abbey.

Besides these original poets, there were some excellent translators. Edward Fairfax translated Tasso's *Jerusalem Delivered* (1600) in a manner worthy of all praise. Sir John Harrington's rendering of Ariosto's *Orlando Furioso* hardly merits such encomium.

Drummond.—The best Scotch poet of the period was William Drummond, of Hawthornden (1585-1649), who rose above provincial fame. Ben Jonson's visit to him in 1618 is a noteworthy incident, for the Scotch poet committed to writing the Englishman's sayings and peculiarities, as another Scotchman did a hundred and fifty years later for another English Johnson. Drummond was an imitator of Spenser and an ardent Royalist. His best poem is *Forth Feasting, a Panegyric to the King's Most Excellent Majesty* (1617).

Robert Burton.—Among the great prose writers of the Stuart period Robert Burton (1577-1640) holds a notable place. He was a clergyman, but spent his life chiefly at Oxford, where he wrote his famous work, *The Anatomy of Melancholy, by Democritus Junior* (1621). The book is crammed with Latin quotations, yet is strikingly original. It fully exhibits his whimsical, melancholy disposition and his multifarious learning. Far from rendering his readers melancholy, he gives them abundant amusement. He made his publisher rich. Sterne and other later writers have been indebted to Burton for quaint passages and curious quotations.

Joseph Hall (1574-1656) rose through various Church preferments to be Bishop of Norwich. He wrote many controversial tracts in favor of Episcopacy, and suffered for his opinions in the time of the Commonwealth. His earliest writings were vigorous rhymed satires bearing the title *Virgidemiarum* (1597). His later writings, explications of Scripture, and *Characters of Virtues and Vices* (1608), were in prose. All were marked with a pithy, sententious style.

Sir Thomas Browne.—A writer of a different style, full of learning and Latinisms, was Dr. Thomas Browne (1605-1682). He was educated at Oxford, and, after extensive travels, settled at Norwich as a physician. His chief books are *Religio Medici* (1642) and *Pseudodoxia Epidemica, or Inquiries into Vulgar and Common Errors* (1646). Though he accepted many scientific errors of the time, he shows much ingenuity, moral courage and depth of religious feeling. He was knighted by Charles II, but his writings appeared before the end of the reign of Charles I.

Thomas Fuller (1608-1661) was a popular preacher and a learned Church historian. Though he dealt with the most serious subjects, he could not refrain from quips and puns. His first large work was *The History of the Holy Warre* (1639)—that is, of the Crusades. More characteristic was the next, called *The Holy and Profane State* (1642), really a collection of moral essays and brief biographies. His last and most popular work is *The History of the Worthies of England,* which appeared posthumously.

Lyric Poets.—When the great conflict of Puritans and Cavaliers was approaching, several of the latter became noted as writers of songs and lyrics. Sir John Suckling (1609-1641) was one of the gayest and liveliest. His playful fancy, polished wit and knowledge of life enabled him to give interest to trifling incidents. His gallantry and munificence made him welcome at the court of Charles I. A richly equipped troop of horse which he presented to the king fled before the Scotch army and brought on their leader many lampoons. Suckling died in Paris, having fled thither after the failure of a plot to release Strafford from the Tower. His few plays possess no interest, but his lively songs and his *Ballad upon a Wedding* are immortal.

Richard Lovelace (1618-1658) was another accomplished cavalier poet. In youth noted for beauty and virtue, he spent his fortune in the king's cause and was thrown into prison. To beguile his time he wrote many poems, which were published in 1649 under the title *Lucasta,* indicating his lady love. Afterward, when released, poor in health and purse, he became an object of charity. He died in a miserable alley in 1658. Some of his poems are affected and obscure, but others are sweet and lively—worthy of lasting remembrance.

TO ALTHEA, FROM PRISON.

When Love, with unconfinéd wings
  Hovers within my gates,
And my divine Althea brings
  To whisper at my grates;
When I lie tangled in her hair,
  And fettered to her eye,
The birds that wanton in the air
  Know no such liberty.

When flowing cups run swiftly round
  With no allaying Thames,
Our careless heads with roses bound,
  Our hearts with loyal flames;
When thirsty grief in wine we steep,
  When healths and draughts go free,
Fishes that tipple in the deep
  Know no such liberty.

When, like committed linnets, I
  With shriller throat shall sing
The sweetness, mercy, majesty,
  And glories of my king;
When I shall voice aloud how good
  He is, how great should be,
Enlarged winds, that curl the flood,
  Know no such liberty.

Stone walls do not a prison make,
  Nor iron bars a cage;
Minds innocent and quiet take
  That for an hermitage:
If I have freedom in my love,
  And in my soul am free;
Angels alone, that soar above,
  Enjoy such liberty.

John Milton.—But, however bright and captivating were the songs of the gallant, dashing cavaliers, the literary glory of this period of religious and political conflict was to rest with the Puritan side. One name alone is sufficient to outweigh the value of all that can be brought forward on the other side. Even if only the shorter poems of Milton's youth are considered, they surpass in merit the plays and lyrics of the opposite party. But they are far from being partisan; they hardly hint at a conflict of opinion; they belong to the pure ether of literature, far above the storms and passions of local and temporary strife. But when to these first fruits are added the great epics of Paradise, produced in his old age and blindness, and the grand concluding tragedy of *Samson Agonistes,* he must be acknowledged the most sublime poet of the English language. As his genius was purely lyric and epic, he did not venture into the actual fields of drama, but tacitly left its supremacy without dispute to the great sovereign of the Elizabethan drama.

John Milton (1608-1674) was of London birth and Cambridge education. His youthful beauty and refined taste and morality procured for him the nickname "the lady of Christ's College." His poetic genius bloomed early, producing a fair array before his twenty-third year. The longest of these was *On the Morning of Christ's Nativity* (1629). After leaving the university he continued his study of the ancient classics and produced new poems. *L'Allegro* and *Il Penseroso* are companion pictures of mirth and melancholy. Their very names attest his study of Italian poets, but in themselves they are classic treatment of English character and scenery. The masque of *Comus* was acted by some of his friends at Ludlow Castle in 1634, but such a poem in praise of virtue and temperance is far removed from the real drama. The elegy of *Lycidas* (1637) was written after the drowning of a college mate. It is modeled strictly in Greek pastoral style, but admits a sharp rebuke of the greedy shepherds of the English Church. Milton, who had early given up any idea of entering the Church, now went to Italy, visiting Florence, Rome and Naples, forming friendships with the learned and conversing with Galileo.

Milton's Prose Works.—He was recalled by the commencement of strife at home, yet years passed in which he composed little poetry, only a few sonnets, some of these in Italian and all in exact Italian form, and grave, tender or grimly playful, as each case required. His chief occupation was pamphlet-writing against Episcopacy. But *Areopagitica, or Speech for the Liberty of Unlicensed Printing* (1644) was a bold and eloquent protest against the censorship of the press. The gifted Puritan poet had married a lady of a Royalist family, and she, discontented when war broke out, went back to her father's house. The aggrieved husband issued pleas for divorce for desertion, yet in the end she was reconciled.

In 1649 Milton was made Latin Secretary of the Commonwealth, Latin being then the language of diplomacy. His *Eikonoklastes* was a reply to the *Eikon Basilike,* in which Dr. Gauden had touchingly portrayed the sufferings of Charles I, while popular belief attributed the work to the king himself. In Latin Milton issued a *Defence of the English People* (1651), a crushing reply to the *Defence of Charles I* by Salnasius, then thought to be the best living Latin scholar. When the undaunted Englishman, in the midst of his labors, lost his sight, he wrote to a friend,

> "I argue not
> Against Heaven's hand or will, nor bate a jot
> Of heart or hope; but still bear up and steer
> Right onward."

He continued his political labors and also began *Paradise Lost,* a subject on which he had determined several years before, when he gave up the idea of writing a national epic on King Arthur. After Cromwell's death he issued some political pamphlets, but they had no effect.

When Charles II was restored to the throne, Milton went into hiding; but that easy-going monarch, when spoken to about the defender of his father's execution, disdained to take vengeance "on an old blind schoolmaster." Milton therefore dwelt in peace in London and finished *Paradise Lost* with the aid of his daughters. It was published in 1667, and for this immortal work the needy author received in all from the publisher the munificent sum of £10. At the suggestion of his Quaker friend, Thomas Ellwood, he afterward added a shorter but equally grand epic on *Paradise Regained* (1671). In four books it describes Christ's victory over the temptation of Satan. There is in it but little action, but many passages are in Milton's grandest style. Along with this epic was published *Samson Agonistes,* a choral drama in the pure Greek style. It represents Samson in his blindness called to make sport for the Philistines, but using his mighty strength to overthrow them, even at the sacrifice of his own life. Samson is here a type not merely of the blind poet, but of the great cause of religion and liberty for which the poet contended. To the end Milton, in spite of blindness, old age and evil times, preserved an inward serenity and imaginative power which enabled his soul to rise triumphantly to loftier spheres.

Paradise Lost.—The grand monumental poem which Milton constructed in his old age, when the cause for which he had labored sank in temporary defeat, is not a mere national epic. It was designed on a grander scale to be the epic of mankind. And yet, in the light of the present day, it is seen to be a wondrous fabric of Puritan theology, as Dante's vision is a grand construction of mediæval Catholic theology. The Protestant Reformation had renounced much of the belief in the spiritual world which had in ages grown up in the Christian Church, but it retained much which was considered to have its roots in passages of the divinely inspired Scriptures. This theology was formulated by Calvin as that of the Middle Ages was systematized by St. Thomas Aquinas. Dante's epic was based on the latter and Milton's on the former, although the poet had evidently modified it so as to give it an Arian aspect.

The fall of Satan, or Lucifer, and the expulsion of rebel angels from Heaven had long been a favorite belief in the Christian Church. It was embodied in the Early English poem of Caedmon, and in Milton's day it had been put in dramatic form by the Dutch poet Vondel. It is not known whether Milton was directly acquainted with either of these productions.

Paradise Lost opens with the awaking of the rebel angels in Hell after their fall from Heaven. They are described with names drawn partly from Scripture and partly from classical mythology, the Pagan deities becoming demons according to early Christian belief. These demons, unrepentant, still hostile to the Almighty, consult how to carry on their conflict. Satan, their chief, announces his determination to go forth and enter the world, where he has heard that Man has been newly created. He passes Sin and Death at the gate of Hell and flies to the earth, where he finds Eden. The beautiful garden and its innocent inhabitants are then described. In the fifth book the Archangel Raphael relates to Adam and Eve the story of the rebellion and war in Heaven, the overthrow of Satan's hosts, and the creation of the world. In the eighth book the temptation and fall of Man is described. The gloom of this part is relieved by the Archangel Michael's showing Adam a vision of the future world, with the promise of Man's redemption by Christ. The poem concludes with the expulsion of our first parents from Paradise.

The entire poem is constructed with the highest artistic skill. The metre is the admiration of all critics. The interweaving of Pagan mythology with Hebrew narrative is wonderfully effective. The whole is an unsurpassed masterpiece of imaginative work.

Milton the Greatest English Poet. — Milton's solid and stainless character furnished the necessary foundation for the rich artistic monument which he erected in his native language. Thoroughly versed in Italian as well as ancient classical poetry, he was able to enrich his own speech with the finest artistic graces. He avoids the faults of Elizabethan poets, equals them in variety and excels them in harmony. In his hands the masque, the sonnet, the elegy, the descriptive lyric and the choral drama were greatly improved; he created the epic in English and molded for it the richest blank verse. He introduced the poetic description of nature. His poetry is never marred by the coarse satire which he sometimes poured out in prose. In Milton the highest influences of the English Renaissance were brought to perfection. While perfectly natural, his method and language were guided by strict rules and severe taste. In every way he was the highest type of the intellectual English Puritan. His great successor, Dryden, acknowledged his surpassing merit in a noble epigram:

Three poets, in three distant ages born,
Greece, Italy and England did adorn.
The first in loftiness of thought surpassed;
The next in majesty; in both the last.
The force of Nature could no further go;
To make a third, she joined the former two.

ATHENS.

(From *Paradise Regained*, Book IV.)

On th' Ægean shore a city stands,
Built nobly, pure the air and light the soil,—
Athens, the eye of Greece, mother of arts
And eloquence, native to famous wits,
Or hospitable, in her sweet recess,
City or suburban, studious walks and shades.
See there the olive grove of Academe,
Plato's retirement, where the Attic bird
Trills her thick-warbled notes the summer long;
There flowery hill Hymettus with the sound
Of bees' industrious murmur oft invites
To studious musing; there Ilissus rolls
His whisp'ring stream. Within the walls then view
The schools of ancient sages; his who bred
Great Alexander to subdue the world;
Lyceum there, and painted Stoa next:
There thou shalt hear and learn the secret power
Of harmony, in tones and numbers hit
By voice or hand, various-measured verse,
Æolian charms and Dorian lyric odes,
And his who gave them breath, but higher sung,
Blind Melesigenes, thence Homer call'd,
Whose poem Phœbus challenged for his own.
Thence what the lofty grave tragedians taught
In chorus or iambic, teachers best
Of moral prudence, with delight received
In brief sententious precepts, while they treat
Of fate, and chance, and change in human life;
High actions and high passions best describing.
Thence to the famous orators repair,
Those ancient, whose resistless eloquence
Wielded at will that fierce democratie,
Shook th' arsenal, and fulmin'd over Greece
To Macedon and Artaxerxes' throne.
To sage philosophy next lend thine ear,
From heaven descended to the low-roof'd house

Of Socrates; see there his tenement,
Whom, well inspired the oracle pronounced
Wisest of men; from whose mouth issued forth
Mellifluous streams, that water'd all the schools.

* * * * * * * *

These rules will render thee a king complete
Within thyself; much more with empire join'd.

Cowley.—In marked contrast with Milton, both in politics and poetry, stood Abraham Cowley (1618-1667). Born in London, he early displayed his talent, writing plays when he was ten years old and publishing *Poetical Blossoms* before he was fifteen. English and Latin comedies from his pen were acted while he was a student at Cambridge University. When strife arose between Charles I and the Parliament, Cowley joined the king at Oxford and satirized the Puritans. Afterward he was one of the queen's suite when she went to Paris. On his return in 1660 he published an ode on *The Blessed Restoration.* Though he had been a steadfast Royalist, he received little favor from Charles II, whom he is thought to have offended by allusions in a play to the licentiousness of the court. Cowley's musical and ingenious love poems, published under the title *The Mistress* (1647), had made him popular. His Latin poems gave him esteem with the learned. His longest poem is *Davideis,* relating the history of King David. After translating Pindar's odes successfully he wrote English odes on the Greek model. His lively fancy and noble thoughts caused these to be long admired and imitated. After his retirement from the court, where he was neglected, Cowley wrote his admirable *Essays in Verse and Prose.* It is pleasant to know that Milton openly recognized his merit. One of Macaulay's earliest productions is an imaginary dialogue between Cowley and Milton, in which their different views are lucidly shown and their respective prose styles well imitated.

Eikon Basilike.—Here may be noticed a work, already mentioned, which had powerful political influence—*Eikon Basilike* (the Royal Image). Its subordinate title is *The Portraiture of His Sacred Majesty in his Solitudes and Sufferings.* It was written by Rev. Dr. John Gauden, but published anonymously immediately after the execution of Charles I. It consisted of explanations of the king's policy in various events, and showed his piety in meditations on sufferings and death. These pathetic soliloquies, being given in the first person, were popularly accepted as written by the king himself. They intensified public opinion against the king's execution, and prepared the way for the recall of his son. Immediately after the Restoration, Dr. Gauden was made a bishop by Charles II and otherwise liberally rewarded.

Minor Poets.—In this age of religious controversy and political strife there were many writers who preserved the true spirit of Christianity. Among them none deserves more honorable mention than saintly George Herbert (1593-1633). Born in Wales, he was educated at Cambridge, and after his graduation was chosen orator for the university. He enjoyed the favor of King James, who pronounced Herbert the jewel of the university and kept him at court. At James's death Herbert took orders and henceforth was a model country parson. The pure beauty of his life is expressed in his poems, gathered under the title *The Temple* (1631), and in a posthumous volume, *Priest to the Temple* (1652).

Robert Herrick (1591-1674), also of Cambridge, was a bachelor vicar of more varied character. After seventeen years spent in "dull Devonshire" he was ejected from his parsonage and went to London, where he published his *Hesperides, or Works both Humane and Divine* (1649). Though it contains many pious pieces, he is best remembered by his sprightly love lyrics and witty epigrams. Later he resumed his clerical functions.

More ambitious in style was Giles Fletcher (1584-1623), a doctor of divinity, who celebrated *Christ's Victory and Triumph in Heaven and Earth* (1610). It was an imitation of Spenser, but used a modified Spenserian stanza of eight lines. After his death his elder brother, Phineas Fletcher (1582-1665) published *Purple Island* (1633), a long allegorical poem in a similar stanza of seven lines. The subject is really the human body and soul.

Francis Quarles (1592-1644), in the early part of his career, versified or paraphrased several Scripture histories, but he is best known by his *Emblems Divine and Moral* (1635), in which quaint wood-cuts were explained by ingenious interpretation.

George Wither (1588-1667) in early life was a bold satirist, and suffered imprisonment for his attacks on those in power. Even in prison he rhymed away, producing the fine pastoral, *The Shepherd's Hunting,* and a long, graceful narrative poem, *Faire-Virtue, the Mistress of Philarete.* After his release he printed with his own hand *Britain's Remembrancer* (1628), which recounted his own experience, as well as public events. Like his friend Quarles, he issued a book of *Emblems* (1635), after the fashion which had spread from Italy to Northern Europe. Always a firm Puritan, Wither served in the Parliamentary army as captain and major.

Richard Crashaw (1613-1649) was the son of a Puritan preacher, and a graduate of Cambridge University. Always deeply devotional and ascetical, he was driven from his fellowship for refusing to subscribe to the Presbyterian Covenant. Withdrawing to France, he became a Roman Catholic and afterward was made canon of a church in Italy. His English poems, *Steps to the Temple* (1646) are evident imitations of Herbert's style, yet highly original in thought and musical in expression. His friend Cowley, in lamenting his death, addresses him as "poet and saint."

CHAPTER V.

From the Restoration to Queen Anne.

A. D. 1660—1700.

The Restoration.—Charles II is known as the merry monarch. Though he had been brought up in exile, neither his own experience nor his father's fate had taught wisdom or dignity. His easy temper and love of pleasure had kept him surrounded with flatterers and evil companions. When he returned to England he brought with him dissipated followers and foreign adventurers. The loyal Englishmen who had made sacrifices in his father's cause and suffered under Cromwell's rule eagerly expected and enthusiastically welcomed the legitimate king. Soon they were dismayed to find themselves thrust in the background, while gamblers and libertines found favor at court. The restraints which had been imposed on rulers and people by Puritanism were done away. King and courtiers engaged in a reckless pursuit of pleasure, and the contagion spread among all classes, especially in London, once the stronghold of Puritanism. The theatres were reopened and public amusements of all kinds were encouraged to excess. The popular literature of the time reflected the moral change produced by the Restoration. Puritanism became a subject of mockery and satire. The fashions of the French court became the standard of taste.

Samuel Butler.—The earliest prominent literary production of this period is the keen satire of *Hudibras,* the first part of which was published in 1662, the second in 1664. Its author was Samuel Butler (1612-1680), a man of low birth, who had studied at Cambridge but was unable to complete his course there. Yet afterward, as clerk or secretary, he made further progress. He was a tutor in the family of Sir Samuel Luke, a wealthy Presbyterian officeholder under Cromwell. It was this man that Butler caricatured in Sir Hudibras, who is represented as an ugly, hypocritical coward. His rude, cross-grained clerk, Ralph, represents the coarser dogmatic Independents. This ridiculous pair set out on an adventurous expedition like Don Quixote and Sancho Panza. Their first encounter is with a ragged crowd who are leading a bear to be baited. When these clowns refuse to disperse a furious combat ensues, in which Hudibras prevails and puts his opponents in the parish stocks. But comrades gather, renew the fight, release their friends and put the interloping knight and squire in the stocks. From this durance vile they are released by a rich widow to whom the knight has been paying attention. Hudibras visits the lady, but is beaten by her servants disguised as devils. He seeks revenge and consults a lawyer and an astrologer. The rambling satire was not brought to a definite conclusion.

Though the idea of this country crusade is evidently borrowed from Cervantes, the manner in which it is developed is entirely different. Butler covers his fanatical characters with odium, while Cervantes excites sympathy for his crazy knight. Yet this English burlesque contains a vast amount of wit, shrewd thought, amusing illustrations and genuine drollery. Butler's concise style, short lines and careless half-rhymes have helped to make his epigrammatic sentences proverbs. But he is destitute of genial humor, and is not able to keep up the interest of his story. Amusing as it is in parts, it soon becomes tedious.

Charles II is said to have carried a copy of *Hudibras* in his pocket and to have been fond of quoting its pungent satire, yet he did nothing for its needy author. Butler had married a wealthy widow and lost her fortune by bad investments. He died in a miserable lodging and was buried at the expense of a friend. After his death some of his miscellaneous writings were published. Among them was *The Elephant in the Moon,* a satire on the newly founded Royal Society.

Edmund Waller. — A more fortunate poet was Edmund Waller (1605-1687). He was a cousin of the statesman John Hampden and also a relative of Cromwell. His love poems were addressed to a daughter of the Earl of Leicester under the name of *Sacharissa,* but the lady married a nobleman. As a member of Parliament Waller was a Liberal, and on Cromwell's death he wrote a fine *Panegyric.* But when Charles II was restored he offered a congratulatory ode. When the king remarked that this was not equal to the other, the witty author replied, "Poets, sire, succeed better in fiction than in truth." Waller continued long to serve in Parliament and was the delight of the House.

Andrew Marvell. — Another poet who served long in Parliament was Andrew Marvell (1621-1678). Well educated, he had been assistant to Milton as Latin Secretary. He wrote a fine poem on the death of Cromwell. His finest is *The Emigrants in the Bermudas.* He satirized the profligacy and arbitrary measures of the court. His prose writings were very popular in their time, but relate chiefly to temporary topics.

Izaak Walton. — Like many another literary worthy and lover of the country, Izaak Walton (1593-1683) was born in London. There, in a cramped room, this favorite author pursued his business as a linen draper till the age of fifty. Then he found time to go a-fishing, and ten years later, while Cromwell was ruling England, he was able to give to the world *The Complete Angler, or Contemplative Man's Recreation.* Four other editions appeared in his lifetime. The author gives minute directions about suitable weather and preparations, about the location of fishing streams, and even about the cooking of trout; but the charm of the book lies in its descriptions of quiet English landscapes and rustic life, varied by a sweet song. Besides this delightful book Walton wrote the biography of five good men. His adopted son, Charles Cotton, added to the *Angler* a Second Part, not unworthy of the First, to make it more complete.

John Dryden.—Although Milton lived and produced his greatest poems in the reign of Charles II, he belonged in spirit to the past age—to the period of Puritan activity and aggression. The true representative of the new era following the Restoration and extending to the end of the seventeenth century, was John Dryden (1631-1700). Nobly gifted both as poet and as prose writer, he so adapted himself to each successive change of courtly and popular fashion that his work becomes a literary embodiment of the times. He was born in Northamptonshire, of good family, and educated at Westminster School and Trinity College, Cambridge. Trained by his father as a Presbyterian, he became secretary to Sir Gilbert Pickering, a prominent official under Cromwell. After the Protector's death in 1658, Dryden published *Heroic Stanzas on the Death of Oliver Cromwell.* The word "heroic" here does not refer to the subject of the elegy, but simply to the kind of verse. Dryden, who was an excellent critic, elsewhere explains that the heroic stanza is an iambic quatrain or stanza of four lines with alternate rhymes—which metre he preferred to the more usual couplet. Gray's *Elegy in a Country Churchyard* furnishes a familiar example of this stanza.

On the 29th of May, 1660, Charles II returned to London amid the cheers of soldiers and people. Dryden, who had, like so many others, changed his side, welcomed the king with *Astræa Redux, a Poem on the Happy Restoration of His Sacred Majesty Charles II.* This effusion is in the ordinary couplet. Its Latin title denotes "the return of Astræa," the goddess of Justice, who had left the earth at the end of the golden age. For the coronation in the next year Dryden contributed an ode, and in due time received his reward, being appointed Poet Laureate in 1668. Before this he had described in heroic stanzas *Annus Mirabilis,* the wonderful year—1665—rendered forever memorable by the great plague of London, followed by the great fire, and by a great naval battle with the Dutch. Three hundred stanzas were necessary to describe all that had happened in that year.

Dryden had married the daughter of the Earl of Berkshire, and thus acquired a high social position. He was now the literary monarch of England, ruling from his chair in Will's Coffee-house, a place frequented by the wealthy and the witty. The fashion of the times required that he should write plays, and so he did—rhymed heroic plays, carefully constructed. A crowd of flatterers approved his work, and the multitude applauded. Yet his power was not undisputed. Thomas Shadwell, an envious rival playwright, attacked him in verse, and Dryden retorted with his *Mac Flecknoe,* pointing out Shadwell as the true heir to the throne of dulness since the death of Flecknoe, a notoriously worthless scribbler.

A more severe attack on Dryden's reputation was the Duke of Buckingham's *Rehearsal,* a play in which the laureate was represented by the poet Bayes, and his mode of producing plays was exposed to ridicule. Dryden felt the blow still more because the king showed his enjoyment of the caricature. But soon the mighty genius found an opportunity for revenge. The Duke of Monmouth—Charles' natural son—was put forward by a faction as better entitled to the succession to the throne than James, the Duke of York, who was an avowed Roman Catholic. Dryden satirized the movement in his *Absalom and Ahithophel,* employing the striking parallel from Scripture history. Charles was King David, Monmouth was Absalom, the plotting

Shaftesbury was Ahithophel, and the magnificent Buckingham was made Zimri:

"A man so various that he seemed to be
Not one, but all mankind's epitome:
Stiff in opinions, always in the wrong;
Was everything by turns and nothing long,
But in the course of one revolving moon
Was chymist, fiddler, statesman and buffoon;
Then all for women, painting, rhyming, drinking,
Besides ten thousand freaks that died in thinking."

While thus severe in exposing the treacherous courtiers, Dryden was discreet and tactful in his portrait of Absalom, the king's favorite son, and represented him as led astray by evil counselors and but half consenting to their plot. In the next reign the foolish Monmouth expiated his treason with his blood.

Dryden went on writing his heroic plays. So completely was he convinced of the improvement of the drama introduced by the new school of criticism in France that he ventured to reconstruct Shakespeare's great historical play, *Anthony and Cleopatra,* and presented it under the title *All for Love, or the World Well Lost.* Yet, with all his genius and ingenuity, he was unable really to convince the stubborn British public. They admired his work and approved it for a time, but in the end they returned with renewed zest to their beloved Shakespeare.

In 1685 the profligate King Charles died after a brief illness. On his deathbed he had been received into the Catholic communion by a priest hastily summoned. Dryden, as laureate, composed a formal elegy without indication of any real grief. The Duke of York succeeded to the throne as James II. He was determined to restore the realm to Catholicism. Dryden did not long delay his conversion. Though he had ably defended the Church of England and its doctrines in his *Religio Laici,* he now published an allegory called *The Hind and the Panther,* in which Catholicism was typified by the timid, milk-white hind, while the Anglican Church was represented by the beautiful but destructive panther. Other creeds or sects were represented by the bloody bear, the quaking hare, the bristled boar. These strange beasts discuss subtle questions of theology, and the spotless hind is, of course, victorious in argument.

The people of England, however, refused to submit to King James's arbitrary policy. They must have a king, and they summoned the Protestant Dutchman, William of Orange, James's son-in-law, to their aid. James, fearing his father's fate, fled to France. William and Mary were welcomed and crowned together. Dryden, at the age of sixty, lost his post as laureate. He had other misfortunes. His uncongenial wife became insane. But the resolute poet did not cease from his wonted labors. He translated Vergil; he modernized several of Chaucer's *Canterbury Tales;* he wrote new dramas for the stage until the public grew weary of heroic plays. His *Vergil* preserves well the sense and spirit of the original, but does not always maintain its dignity. His tales from Chaucer are often expansions of the early poets simple narrative, embellished with modern ornament. Among his later plays *Don Sebastian* holds high rank. But the best performance of his laborious old age was his lyrical odes. He seems to have devoted his best power to St. Cecilia, "the inventress of the vocal frame." For one of her festivals he wrote a fine song; for another, the ode on *Alexander's Feast,* which is here given.

Dryden is acknowledged by critics to be a master of prose as well as of verse. The prose is seen to advantage in his *Essay on Dramatic Poetry,* and in the prefaces and dedications to his numerous plays and poems. His well-argued criticisms did much to improve the general tone of poetry. Even in his poetry his strength often lies in his concise reasoning and happy illustrations. His facility in rhyming seems to have rendered him unjust in his censure of blank verse. Shakespeare had gradually diminished the use of rhyme in his plays, but Dryden insisted on it as essential; yet in his latest plays he freely used blank verse. Great as are the merits of his productions, readers in general show little inclination to them. Perhaps this neglect is due to an unconscious distrust of the man whose wavering course has been related—to a doubt of his sincerity. Though to the end he adhered to the Catholic faith, a monument was erected to his memory in Westminster Abbey, bearing only his name and date.

ALEXANDER'S FEAST; OR, THE POWER OF MUSIC.

A song in honor of St. Cecilia's Day, 1697.

'Twas at the royal feast for Persia won
By Philip's warlike son:
Aloft in awful state
The godlike hero sate
On his imperial throne;
His valiant peers were placed around;
Their brows with roses and with myrtles bound:
(So should desert in arms be crowned.)
The lovely Thais, by his side,
Sate like a blooming Eastern bride,
In flower of youth and beauty's pride.
Happy, happy, happy pair!

None but the brave,
None but the brave,
None but the brave deserves the fair.

Timotheus, placed on high
Amid the tuneful quire,
With flying fingers touched the lyre:
The trembling notes ascend the sky,
And heavenly joys inspire.
The song began from Jove,
Who left his blissful seats above,
(Such is the power of mighty love.)
A dragon's fiery form belied the god:
Sublime on radiant spires he rode,
When he to fair Olympia pressed;
And while he sought her snowy breast,
Then round her slender waist he curled,
And stamped an image of himself, a sovereign of the world.
The listening crowd admire the lofty sound,
A present deity, they shout around;
A present deity, the vaulted roofs rebound:
With ravished ears
The monarch hears,
Assumes the god,
Affects to nod,
And seems to shake the spheres.

The praise of Bacchus then the sweet musician sung,
Of Bacchus ever fair, and ever young.
The jolly god in triumph comes;
Sound the trumpets, beat the drums;
Flushed with a purple grace
He shows his honest face:
Now give the hautboys breath; he comes, he comes.
Bacchus, ever fair and young,
Drinking joys did first ordain;
Bacchus' blessings are a treasure,
Drinking is the soldier's pleasure;
Rich the treasure,
Sweet the pleasure,
Sweet is pleasure after pain.

Soothed with the sound the king grew vain;
Fought all his battles o'er again;
And thrice he routed all his foes, and thrice he slew the slain.
The master saw the madness rise,
His glowing cheeks, his ardent eyes;
And while he heaven and earth defied,
Changed his hand, and checked his pride.
He chose a mournful Muse,
Soft pity to infuse;
He sung Darius great and good,
By too severe a fate,
Fallen, fallen, fallen, fallen,
Fallen from his high estate,
And weltering in his blood;
Deserted at his utmost need
By those his former bounty fed;
On the bare earth exposed he lies,
With not a friend to close his eyes.
With downcast looks the joyless victor sate,
Revolving in his altered soul
The various turns of chance below:
And, now and then, a sigh he stole,
And tears began to flow.

The mighty master smiled to see
That love was in the next degree;
'Twas but a kindred-sound to move,
For pity melts the mind to love.
Softly sweet, in Lydian measures,
Soon he soothed his soul to pleasures.
War, he sung, is toil and trouble;
Honor but an empty bubble;
Never ending, still beginning,
Fighting still, and still destroying:
If the world be worth thy winning,
Think, O think it worth enjoying:
Lovely Thais sits beside thee,
Take the good the gods provide thee.
The many rend the skies with loud applause;
So Love was crowned, but Music won the cause.
The prince, unable to conceal his pain,
Gazed on the fair
Who caused his care,
And sighed and looked, sighed and looked,
Sighed and looked, and sighed again;
At length, with love and wine at once oppressed,
The vanquished victor sunk upon her breast.

Now strike the golden lyre again;
A louder yet, and yet a louder strain.
Break his bands of sleep asunder,
And rouse him, like a rattling peal of thunder.
Hark, hark, the horrid sound
Has raised up his head;
As awaked from the dead,
And, amazed, he stares around.
"Revenge, revenge!" Timotheus cries;
"See the Furies arise;
See the snakes that they rear,
How they hiss in their hair,
And the sparkles that flash from their eyes!
Behold a ghastly band,
Each a torch in his hand!
Those are Grecian ghosts, that in battle were slain,
And unburied remain
Inglorious on the plain:
Give the vengeance due
To the valiant crew.
Behold how they toss their torches on high,
How they point to the Persian abodes,
And glittering temples of their hostile gods."
The princes applaud with a furious joy;
And the king seized a flambeau with zeal to destroy;
Thais led the way,
To light him to his prey,
And, like another Helen, fired another Troy.

Thus long ago,
Ere heaving bellows learned to blow,
While organs yet were mute,
Timotheus, to his breathing flute
And sounding lyre,
Could swell the soul to rage, or kindle soft desire.
At last divine Cecilia came,
Inventress of the vocal frame;
The sweet enthusiast, from her sacred store,
Enlarged the former narrow bounds,
And added length to solemn sounds,
With Nature's mother-wit, and arts unknown before.
Let old Timotheus yield the prize,
Or both divide the crown:
He raised a mortal to the skies;
She drew an angel down.

Minor Poets.—Among the lesser lights of the period were several noblemen—the Earl of Dorset, the Earl of Roscommon, the Earl of Rochester and Sir Charles Sedley. The trifling songs of the last two were more to the taste of king and court than the serious attempts of the others. The Duke of Buckingham's comedy ridiculing Dryden has already been mentioned. To religious poetry the chief contribution was Bishop Ken's *Morning and Evening Hymns* (1668), from the latter of which comes the familiar long-metre doxology, "Praise God, from whom all blessings flow."

Prose Literature.—Much of the prose of this period treats of religious and political subjects. The spiritual enthusiasm which had followed the Reformation and the diffusion of the English Bible had subsided. Numerous sects and religious leaders had appeared in the reign of Charles I. The fundamental principles of religion and government were warmly discussed. After the failure of the Commonwealth and the restoration of the monarchy the controversy continued. Churchmen, Presbyterians, Baptists, and Friends or Quakers, all labored to explain their views of truth and to convince others. In the reign of Charles II the Established Church had several distinguished preachers, among whom were the ponderously argumentative Barrow, the perspicuous, convincing Tillotson, the sincerely pious Leighton and the witty, colloquial South. But the best known of them all is Bishop Jeremy Taylor (1613-1667). He had been a chaplain to Charles I, was patronized by Archbishop Laud, suffered for his loyalty and was at last rewarded by Charles II, who made him bishop of Dromore in Ireland. Early in his career he published *Liberty of Prophesying* (1647), in which he advocated allowing great liberty of opinion to all who accepted the Apostles' Creed. His more famous books were devotional, especially *The Golden Grove* and *The Rule and Exercises of Holy Living and Holy Dying*, which have been highly praised by Catholics as well as Protestants.

One of the most voluminous writers was the Presbyterian, Richard Baxter (1615-1691), who labored for union among Christians, yet was persecuted and imprisoned for preaching. His most popular work is *The Saints' Everlasting Rest.*

George Fox (1624-1690) had little education, but, believing himself divinely called, traveled through England, preaching repentance. The result of his labors was the founding of the Society of Friends, who soon received the nickname Quakers. The *Journal of His Life and Travels* is highly interesting. The learned Scotchman, Robert Barclay (1648-1690), who had become a disciple of Fox, published his *Apology for the True Christian Divinity* (1676), first in Latin and then in English. Instead of a dedication, it contained an address to the king, pleading for justice to the suffering Friends. More widely known historically is William Penn (1644-1718), who, besides publishing many books in behalf of Quaker faith and practice, devoted arduous labor and the bulk of his fortune to the "holy experiment" of founding in the wilderness of America a settlement and government illustrating Quaker principles. To Fox's *Journal* he prefixed *A Brief Account of the Rise and Progress of the People Called Quakers* (1694). His most popular work, *No Cross, No Crown* (1669), was written during an imprisonment in the Tower of London. Though he had abundant flow of language, his style is awkward, but his earnestness often makes it impressive.

John Bunyan. — The religious writer of this period whose work eventually obtained the highest honor and the widest circulation was the Baptist preacher, John Bunyan (1628-1688). He was born at Elstow, of poor parents. At the age of seventeen he became a soldier in the civil war, probably on the parliamentary side. After the war he married a poor woman and was converted by a book she brought him. Living in Bedford, a tinker by trade, he became active in a small independent religious society. Here he began to preach, and afterward visited the villages around Bedford for the same purpose. Having had a controversy with the Quakers, he published his views in his first book, *Some Gospel Truths Opened* (1656). When the law in 1660 prohibited non-conformist conventicles, Bunyan was arrested and cast into Bedford jail. During his imprisonment of twelve years he preached to those who gathered near the jail window, and wrote several books. One of them, *Grace Abounding to the Chief of Sinners,* is partly autobiographical. He was released by the Declaration of Indulgence in 1672, and became a licensed preacher under that act. Before three years had elapsed this act was repealed and Bunyan was again imprisoned. During the six months of his confinement he wrote the first part of his immortal *Pilgrim's Progress* (1677). This picturesque allegory of the Christian life, its struggles with sin and temptation, and its final triumph and reward, found many readers. It was enlarged in later editions, and the Second Part, containing the story of Christiana and her children, was added in 1684. In the meantime Bunyan had written his next best work, *The Holy War* (1682), another allegory describing the contest between Diabolus and Shaddai for the possession of man's soul, here represented as a walled town. Bunyan was pastor of the Baptist Church at Bedford for sixteen years. In 1688, while journeying to London, he was exposed to a storm, became ill and died at a friend's house. He was buried in Bunhill Fields, London. During his lifetime 100,000 copies of the *Pilgrim's Progress* were sold. It was illustrated with engravings in 1685. It has since been translated into nearly one hundred languages. Bunyan had written altogether sixty volumes, but only those here mentioned have become popular. Strange to say, a hundred years after his death, the poet Cowper, praising his work, declined to mention the author's name, on the ground that it was too obscure. But the time for such tame, halting criticism is past. Bunyan's genius has raised him to an assured position in English literature. Southey, Froude and others have written biographies of the immortal dreamer.

The Restoration Drama.—The Puritan party was driven from power; non-conformity was rigidly suppressed; members of the various sects sought shelter in obscurity. The king and his associates had seen in France Molière's witty comedies of everyday life. They demanded something of the same kind for the theatres which had been reopened. Dryden and others hastened to comply. Their comedies were degraded to the immoral sentiment of their patrons. But the sturdy Englishmen lacked the airy grace of the French. They passed the limit which Molière and his countrymen instinctively recognized. Seeking to cater to depraved tastes, they revelled in grossness. They filled their comedies with low wit and curious intrigues.

William Wycherley (1640-1715), who had been educated in the household of a French noble, was the first to introduce the new style of the drama. In 1672 he presented *Love in a Wood,* and afterward followed it up with *The Gentleman Dancing Master* and *The Country Wife.* The main ideas of these were derived from Molière, but they were much changed, even what was pure in the original was rendered unclean. The dialogue was lively and amusing, and sudden transitions produced striking situations. The eminent French critic, Taine, says: "His style is labored and troublesome to read. His tone is virulent and bitter. He forces his comedy to get at spiteful satire." Wycherley lost the favor of the court by an unfortunate marriage with a countess, whose jealousy worried him. After her death he spent seven years in prison for debt.

William Congreve (1670-1729) was the ablest of these comic dramatists. At Trinity College, Dublin, he had received an excellent classical education. When he went to London he lived as a man of fashion, and employed his leisure in writing plays. The first was *The Old Bachelor* (1693). It was quickly followed by four others, of which *Love for Love* (1695) is the best. They were all received with favor by the public and the critics. The dialogues were faithful transcripts of the conversation of fashionable life, heightened by sparkling wit. But the characters were artificial, according to the affected fashion of the time. Voltaire, when living in England, visited Congreve, and pronounced him the best comedy-writer that country had ever known. Congreve's only attempt at tragedy is *The Mourning Bride* (1697), a pompous play, which was highly applauded when first given, but afterward condemned as untrue to nature.

Later came Sir John Vanbrugh (1666-1726), who was a famous architect. His comedies were coarse adaptations from Molière, and the characters, fops, squires and intriguing dames, were drawn more naturally than in the earlier plays.

There were other comic dramatists who need not be named. Plays of this class supplied the theatres through most of the eighteenth century in spite of the vigorous protests of Jeremy Collier (1650-1720) and other moralists. In his *Short View of the Immorality and Profaneness of the English Stage,* Collier boldly attacked Dryden and Congreve, both then at the height of their reputations. Dryden openly confessed his fault. Others who were attacked made a poor defence. Gradually public sentiment was reformed. In the end the vicious plays were withdrawn from the boards.

Tragic Dramatists. — Thomas Otway (1651-1685) approached most closely to the style and power of the Elizabethan dramatists. He began as an imitator of Dryden, but afterward developed originality. Of his seven tragedies, two still keep the stage—*The Orphan* and *Venice Preserved.* He excelled in pathos, and, indeed, carried scenes of distress to an extreme. His life was wretched; his love was spurned by an actress, and he is said to have died of starvation.

Another unfortunate dramatist was Nathaniel Lee (1657-1692). He assisted Dryden in several heroic plays, and in his own tragedies acquired a high reputation. His exaggerated style resembles that of Marlowe. In his tragedy of *Alexander the Great* occurs a line which is the basis of a familiar quotation· "When Greeks join'd Greeks, then was the tug of war." Poor Lee was subject to fits of insanity and died in a mad-house.

Nicholas Rowe (1673-1718) furnishes a happy contrast to the preceding. He was wealthy, held lucrative offices and was made poet laureate. Of his seven tragedies, *Jane Shore* and *The Fair Penitent* are the best known. Rowe was the first to undertake the critical editing of Shakespeare.

Clarendon.—The career of Edward Hyde (1609-1674), who was made, at the Restoration, Earl of Clarendon and Lord Chancellor, belongs to the history of England. His daughter Anne became the wife of James II and mother of Mary, who, with her husband William, Prince of Orange, succeeded to the throne. Clarendon, being impeached by the House of Commons, fell from his lofty position in 1667. He retired to France, where he died in 1674. All his literary works were published after his death, one as late as 1759. The principal one, occupying three folio volumes, is his grand and stately *History of the Rebellion and Civil War in England* (1704). It contains much of his direct observation of events, and is especially noted for its elaborate characters of the principal actors. It was intended to be accurate, but is, of course, strongly partisan; yet it has remained the chief authority for its period until recent times. The later *Account of His Life* serves as a continuation to the history, and has the same merit.

Evelyn and Pepys.—Two notable diaries have brought the life and manners of this period vividly before later readers. The first is that of John Evelyn (1620-1706), which begins about 1641. He was an earnest, high-minded, wealthy Churchman, who traveled to Italy for education, sojourned for some time in Paris with other English exiles, but returned to his native country during the Commonwealth period. He composed big folios on architecture and forestry, now neglected. Profound was his rejoicing at the Restoration, but deep was his grief at the vile conduct of Charles II. His account of the great fire of London is most vivid. He gives a sad picture of the death of Charles. The other diarist is Samuel Pepys (1633-1708), son of a London tailor, educated at Cambridge, and a trusty official in the naval department. His work covers only ten years, commencing in 1660. While it fairly describes the great plague and the great fire of London, as well as other important events, its interest lies in the speech and actions of the writer himself. It was written in a difficult shorthand, which was not deciphered until 1825. Since that time several editions have been published. Pepys, writing only for himself, sets down faithfully his sins and follies, his fondness for drink and pretty women, his steady routine of work, his church attendance and his occasional dissipations, his shrewd observations on people of all sorts whom he chanced to meet. The literary men who tried by narrative, satire and dramas to depict their age are outdone by this brisk business man, who jotted down at random his daily doings and viewings. He had a practical acquaintance with science, such as it was in those days, and in due time was made President of the Royal Society, which had been instituted in the days of King Charles, and was so named in his honor. But the science of those times has decayed, while the diarist's graphic illustrations of human nature have preserved their freshness.

CHAPTER VI.

Literature from Queen Anne to George II.

A. D. 1700—1750.

The literature of the beginning of the eighteenth century has been distinguished by the name of Queen Anne, as that of the sixteenth is by Elizabeth, and that of the latter part of the nineteenth by Victoria. The Revolution of 1688, which brought William of Orange to the throne, established the government of Great Britain as a limited constitutional Protestant monarchy. Two strong parties now appeared, bearing the nicknames of Whig and Tory. The struggle between them, was carried on by appeals to the people. Pamphlets and folios had served this purpose in the seventeenth century, but now newspapers, which had begun to appear in the Parliamentary war, were utilized for a new object—the discussion of politics—by which their character was vitally changed. The party leaders engaged ready prose-writers to direct public opinion. Most of the literature of the time bears the stamp of party struggle. Personal satire flourished. The general result was the lowering of the ablest writers and a conflict, both pitiful and pitiless, among the meaner sort.

The influence of France, which had altered English literature after the Restoration, still continued. The criticism of Boileau affected English style as well as French. The long Latinized periodic sentences of the seventeenth century gave place to the clear, brisk style of Addison and Swift. The study of city life, which formed the staple of the Restoration drama, led to a new form of essays both in prose and poetry. Soon the novel made its appearance and was welcomed. Literature, abandoning remote heights, condescended to mingle with the common people.

It may be noted in passing that "good Queen Anne," though much praised by the leading writers, cared little for literature. She was short and stout, with loose, flowing hair, and arms which the painter, Sir Godfrey Kneller, pronounced the finest in the kingdom. She owed her throne to the Whig party, and for some years they had the ascendency, but later the Tories, whom she preferred, came into power. Though Anne had many children, none of them survived infancy. The crown therefore passed from the House of Stuart, and in order to secure a Protestant succession, went to George the Elector of Hanover, who could not speak a word of English, and did not care to learn. He and his son George II were stupid and good-natured, and left the management of public affairs to their ministers.

Addison and Steele. — The most illustrious prose-writer of this period was Joseph Addison (1673-1719). The son of a clergyman, he was a pupil in the Charterhouse School in London, and completed his education at Magdalen College, Oxford. By a poetical *Address* he won the favor of Dryden. His eulogy on William III was well rewarded, enabling him to travel in France and Italy. His *Poetical Letter from Italy* increased his reputation. After his return he was invited by Godolphin to celebrate Marlborough's victory at Bleheim. His poem of *The Campaign* (1704) ensured him prosperity. He was made Under-Secretary of State and held other lucrative positions. His *Travels in Italy* and some minor productions were esteemed, but his fame was to come from a different source.

His schoolmate, Sir Richard Steele (1672-1729), had a varied career. Full of good intentions, but too fond of pleasure, he spent his time in getting into scrapes and making projects of reformation. He had enlisted as a private soldier, then was promoted to a commission, and gave way to riotous conduct. To help his own reform, he wrote a pious treatise called *The Christian Soldier.* When his ready pen produced party pamphlets, the Government appointed him to edit the *Gazette.* Having thus a monopoly of official news, he began publishing a penny sheet called *The Tatler,* which, besides news, contained regularly a short essay, treating social topics with good taste and pure morality. For nearly two years *The Tatler* appeared regularly thrice a week. Then, by a turn in politics, Steele lost his position as Gazetteer and gave up the paper. Two months later Addison started *The Spectator* as a daily journal of similar type. With the aid of Steele and a few others it was enabled to reach No. 555. Then a stamp act quenched its light. After eighteen months' interval it was rekindled for a brief period. *The Guardian* succeeded it, but though Addison and Steele were contributors, it never attained the high reputation of *The Spectator.* Addison had contributed to *The Tatler* about one-sixth, to *The Spectator* more than half, to *The Guardian* one-third of its matter. The wonderful variety of the subjects and the felicity with which they are treated still excite admiration. From ladies' fashions and fads to the most serious concerns of life, everything is treated in appropriate and refined style. Above all, the characters of men are carefully delineated. Sir Roger de Coverley remains the type of the well-to-do English squire, honest and virtuous, not without foibles. His dependants, the butler, the chaplain and Will Wimble, are not less faithfully depicted. These charming sketches give Addison high rank among the painters of human nature. His critical essays on Milton helped to remove the prejudice against the republican poet.

During the suspension of *The Spectator,* Addison finished and brought out his tragedy of *Cato* (1713). It was composed with strict regard for the classical unities and all the rules which French critics had imposed upon dramatic poets. It abounded in patriotic and virtuous rhetoric. Large crowds attended its production, and both Whigs and Tories applauded its political sentiments. But after the first outburst their ardor cooled, and the play was seen only in print.

Addison was naturally a reserved, timid person, yet he was fond of his club. His only fault was too much indulgence in wine, yet perhaps he did not transgress the habits of his age. In 1716 he married the Countess Dowager of Warwick, and soon afterward was made Secretary of State. When he retired on a pension he hoped to devote himself to religious writing. But he was soon cut off, having been afflicted with asthma. Macaulay says of him, "He knew how to use wit without abusing it. Without inflicting a wound he effected a great social reform and reconciled wit and virtue."

Steele started several more periodicals, *The Englishman, Town Talk, The Theatre,* etc., but none of them met with success. He was a steadfast Whig, and the Tories, whom the queen had always preferred, gained the upper hand. After her death, Steele obtained lucrative offices and was knighted by King George in 1715. But his imprudence brought on new troubles. In 1724 he retired to Wales, and there died five years later. Macaulay says of him, "His temper was sweet, his affections warm, his passions strong and his principles weak." For the stage he had written a number of comedies, the best being *The Conscious Lovers*. But his great contribution to literature was originating the periodical essay and purifying the tone of prose writing.

Jonathan Swift.—Far more powerful in intellectual force than Addison, and more copious in production, Jonathan Swift (1667-1745) failed to attain equal fortune or reputation. Born in Dublin and early left an orphan, he was brought up by patrons. After leaving Trinity College he became secretary to Sir William Temple, and thus obtained intimate knowledge of Whig politics. He was a prodigious reader and prolific writer. His first important production was *The Battle of the Books* (1697). In it he supported Temple's rash assertions about ancient literature and ridiculed Richard Bentley, the greatest classical scholar England has ever produced. Swift was ordained a clergyman and became vicar of Laracor. *The Tale of a Tub* (1704) is a whimsical allegory, satirizing the Roman Church and the Calvinists and approving the Church of England. But it did not help him to favor with the church authorities. He induced Miss Esther Johnson, who had been a dependant of Sir William Temple and his own pupil, to come to Ireland with a Mrs. Dingley, and held out the prospect of marriage. After a time Esther Vanhomrigh became infatuated with the vivacious clergyman. When he was made Dean of St. Patrick's Cathedral, he trifled with the affections of both women. When he consented to a private marriage with Miss Johnson, whom he called Stella, he stipulated that it should never be made known. Yet he continued to write love verses to Miss Vanhomrigh, whom he styled Vanessa. At last the latter wrote to Miss Johnson, inquiring about the alleged marriage, and Stella acknowledged the fact. Then the Dean, in a furious passion, called on Miss Vanhomrigh, flung her letter to Stella on the table and rushed out. Vanessa died in a few weeks, but left their correspondence for publication. Stella lived five years longer to endure the Dean's cruel treatment.

In spite of his unclerical writings and conduct, Swift had hoped to be made a bishop by the Whig ministry, in reward for his political services. Then he went over to the Tories, who soon came into power. Their leaders eagerly welcomed him, and to them he owed his deanery. But his *Tale of a Tub* and other writings obstructed his further promotion. Still he wrote vigorous pamphlets on *The Public Spirit of the Whigs, The Conduct of the Allies* and *Reflections on the Barrier Treaty*. These writings reconciled the nation to the peace policy of the Tory ministry and kindled a feeling of enthusiasm for the Tory leaders. But these leaders quarreled among themselves, and their affairs became desperate. During his frequent visits to London, Swift had joined with Pope, Arbuthnot and others in forming the Scriblerus Club, to whose *Miscellanies* all contributed.

When Swift returned to Ireland to stay, he found the people thoroughly disgusted with his conduct. He himself was deeply chagrined, but he bided his time for revenge on English statesmen. At last, full of bitterness for his treatment, he took up the cause of the oppressed Irish people. In his *Proposal for the Universal Use of Irish Manufactures* (1720), published anonymously, he urged the Irish to buy no English goods. Then in 1724 he published the *Drapier Letters*, denouncing the fraudulent contract which the Government had made with Wood to supply copper coins for Ireland. The popular tumult aroused by it was so great that Wood's privilege was revoked.

Gulliver's Travels (1726) was the next caustic satire from Swift's pen. It was intended to ridicule Whigs and Tories, king and ministers, and even mankind in general. But the story, with all its extravagant absurdities, was written in such straightforward style that it was read for mere entertainment. And so it has held its place to this day.

Many minor squibs and skits were issued by this terrible master of ridicule. When the learned Robert Boyle attempted to combine pious reflections with accounts of scientific experiments, Swift retorted with *Meditations on a Broomstick*. In his *Directions for Servants* and *Polite Conversation* he satirized contemporary manners. Carlyle's *Sartor Resartus* was anticipated in some of Swift's writings.

The death of Stella and the loss of other friends deepened the gloom which had fallen on Swift's sombre spirit. He was deprived of the pleasure of society by deafness. He had forebodings of insanity which were to be realized. Speaking to Dr. Young of a noble tree whose upper branches were withered, he said, "I shall be like that tree; I shall die at the top." In 1741 he lost his reason, yet he lingered four years. He was buried in St. Patrick's Cathedral, Dublin. On his tomb is a

Latin epitaph composed by himself, in which he speaks of resting "where fierce indignation can no further rend his heart."

In his epitaph Swift claimed for himself the credit of having been a fearless vindicator of popular rights, and his claim must be admitted. While he shamefully disgraced his profession, and even outraged common decency, he did belabor unworthy possessors of power. His *Verses on the Death of Dr. Swift* describe in a satirical yet truthful way how that event and his own character would be discussed by his friends, his foes and his acquaintances. His fame rests on his masterly prose. His vocabulary is genuine English, free from foreign admixture.

Arbuthnot.—Among Swift's literary associates was the witty, good-natured Dr. John Arbuthnot (1667-1735). He was a Scotch physician attached to the court. He was probably the originator of the *Memoirs of Martinus Scriblerus,* a satire on the abuses of learning, to which his friends gladly contributed. His special fame is based on *The History of John Bull,* in which the intrigues and wars of that time are laughably caricatured. The name and personal character of John Bull, as typifying England, are entirely due to Arbuthnot's burlesque. The other characters are Lewis Baboon (France), Nick Frog (Holland), Lord Strutt (Spain), Squire South (Austria).

Bolingbroke.—Another member of that brilliant society was Henry St. John, Viscount Bolingbroke (1678-1751). While in his prime he was an active statesman and brilliant orator. He was Secretary of State in the last years of Queen Anne, when the Tories were in the ascendancy. In 1715 he was impeached for high treason by Sir Robert Walpole and driven into exile. His offence was his dealings with the Stuart Pretender. He became Secretary of State to the latter, who made him an Earl. When the Pretender invaded Scotland against his advice, Bolingbroke gave up his place and turned to philosophy. In 1723 he was permitted to return to England and have his property restored, but not his peerage. He had much influence on the poet Pope and suggested his *Essay on Man.* Besides contributions to periodicals, he wrote *A Dissertation on Parties* and a *History of England.* His *Philosophical Writings* were collected and published in 1754.

Alexander Pope.—The great poet of this so-called Augustan age was Alexander Pope (1688-1744). By him the vigor and majestic regularity of Dryden were yet more highly polished. The age was critical and philosophical. Human nature as seen in civilized society was its usual theme. Satire, social and political, flourished. The best poetical expression of its spirit and tendencies is found in the works of Pope.

He was born in London of a Catholic family, and he adhered to that faith through his life. His body was dwarfish and deformed, weak and sickly, so that he was once compared to an interrogation mark—"a little crooked thing that asks questions." But his mind was precocious. Referring to his early attempts at verse, he says:

> As yet a child, and all unknown to fame,
> I lisped in numbers, for the numbers came.

He studied and imitated the verses of Dryden and Spenser. He was much influenced by his friends. Cynical Swift applauded him and Bolingbroke became his counselor. After a few pastorals, Pope's reputation was fixed, at the age of twenty, by his *Essay on Criticism* (1711). In it were arranged the rules gathered from Horace and Boileau and concisely expressed. It is the source of many popular quotations.

The masterpiece of his writing is the charming mock-heroic poem, *The Rape of the Lock.* It was founded on an incident in court-life. The gay Lord Petre had cut a lock of hair from the head of Arabella Fermor, a beautiful maid of honor to the queen. A quarrel had ensued between their families. Pope attempted to quench strife by pleasantry, but is said to have failed. But he did not fail to enhance his own reputation. At first the poem in two cantos did not contain any supernatural characters, but in a second version, enlarged to five cantos, Pope brought in the aid of sylphs and gnomes, and thereby heightened the romantic beauty of the story.

Pope, who in several instances had followed Dryden's example, now undertook the laborious task of translating Homer, as his predecessor had done Vergil. The *Iliad* was completed in 1720. It was published by subscription and brought the poet £7,000. The *Odyssey* appeared five years later, but half of this was done by the assistance of others. The translation is, in general, faithful, and yet it is far from giving the true spirit of the original. As the great scholar, Bentley, said: "It is a very pretty poem, Mr. Pope, but you must not call it Homer." It has been wittily suggested that Dryden and Pope ought to have exchanged subjects for translation. Pope's grace and finish would have happily rendered Vergil. Dryden's robust dexterity would have suited the grand simplicity of Homer.

More famous still is Pope's poetical rendering of the *Epistle of Eloisa to Abelard,* one of the great love episodes of the Middle Ages. Being now able to adjust his style of living to his own fancy, Pope removed to a villa at Twickenham on the Thames. Here he spent the remainder of his days in peaceful comfort, amusing himself with gardening and the society of his friends. His edition of Shakespeare in 1725 testified his regard for the dramatist, but did not do much to elucidate his work.

After some prose contributions to the *Memoirs of Martinus Scriblerus,* Pope returned to verse to wreak vengeance on the poetasters and criticasters who annoyed and envied him. The result is seen in *The Dunciad* (1729), the most sweeping and powerful satire in the English language. The story runs that after the death of Shadwell, whom Dryden scored in his *MacFlecknoe,* the throne of Dulness was vacant until the aspirants should decide by a series of trials, like the Olympic Games, who best deserved to occupy it. In the early editions the palm of stupidity was awarded to Theobald, a rival editor of Shakespeare. In the later (1743), Theobald was degraded and the crown was given to Colley Cibber, an actor who had been made Poet Laureate. The entire poem is a remarkable exhibition of spiteful genius.

In 1731 Pope undertook an imitation of Horace's Epistles, addressing them to his friends, Arbuthnot, Bathurst and others. They are charming reproductions of the spirit of their famous originals. More elaborate were his four epistles addressed to Bolingbroke and constituting the famous *Essay on Man.* It is perhaps the best, certainly the most elegant, philosophical poem in the English language; yet it is far from convincing by its arguments. It was inspired by Bolingbroke, and sets forth his philosophy in a plausible form. Pope afterward returned to Horace, and in his *Imitations* adapted the ideas of the Roman satirist to the persons and vices of his own time. His health failed and he had lost his best friends. He died in May, 1744.

Pope's Quarrel with Addison.—In the early part of his career, Pope paid deference to Addison, then already famous. In return for his commendation of the *Essay on Criticism,* Pope sent to *The Spectator* his *Messiah,* a beautiful adaptation of Vergil's remarkable eclogue, *Pollio.* But later Addison irritated the sensitive poet by criticisms. There were various misunderstandings and political divergence when Pope went over to the Tories. Friends tried in vain to close the widening breach, though occasional compliments passed between them in public. At last Pope inserted in the *Prologue to the Satires* his famous censure of Addison under the name Atticus. Yet when compared with his rancorous attacks on others it is mild and dignified. One of his other victims, stung by his cruelty, called him "the wicked wasp of Twickenham."

There has been much controversy as to Pope's place as a poet, even doubt as to whether he was a real poet. The object of poetry is to excite the imagination or fancy by appropriate thoughts clothed in rhythmical language, and thus gratify the mind. Though Pope did not soar into the pure ether of the imagination, he did in a most lively way stir the fancy and give exquisite pleasure. He studied and practiced the laws of rhythm, and by example and precept made the rhymed couplet almost the standard of English verse. Hundreds of writers, striving to imitate his manner, produced mean and contemptible verse. But their master, Pope, has been justly pronounced "the poet laureate of polite life."

THE BARON CUTS THE FATAL LOCK.

(From *The Rape of the Lock,* Canto V.)

Coffee (which makes the politician wise,
And see through all things with his half-shut eyes)
Sent up in vapors to the Baron's brain
New stratagems the radiant Lock to gain.
Ah cease, rash youth! desist ere 'tis too late,
Fear the just gods, and think of Scylla's fate!
Changed to a bird and sent to flit in air,
She dearly pays for Nisus' injured hair!
  But when to mischief mortals bend their will,
How soon they find fit instruments of ill!
Just then Clarissa drew with tempting grace
A two-edg'd weapon from her shining case;
So ladies, in romance, assist their knight,
Present the spear, and arm him for the fight.
He takes the gift with reverence, and extends
The little engine on his fingers' ends:
This just behind Belinda's neck he spread,
As o'er the fragrant steams she bends her head.
Swift to the Lock a thousand sprites repair,
A thousand wings, by turns, blow back the hair;
And thrice they twitch'd the diamond in her ear;
Thrice she look'd back, and thrice the foe drew near.
Just in that instant anxious Ariel sought
The close recesses of the virgin's thought.
As on the nosegay in her breast reclin'd,
He watch'd th' ideas rising in her mind,
Sudden he view'd, in spite of all her art,
An earthly lover lurking at her heart.
Amaz'd, confus'd, he found his power expir'd,
Resign'd to fate, and with a sigh retir'd.
The Peer now spreads the glittering forfex wide,
T' inclose the Lock; now joins it, to divide.
E'en then, before the fatal engine clos'd,
A wretched sylph too fondly interpos'd;
Fate urg'd the shears, and cut the sylph in twain
(But airy substance soon unites again);
The meeting points the sacred hair dissever

From the fair head for ever and for ever!
Then flash'd the living lightning from her eyes,
And screams of horror rend the affrighted skies.
Not louder shrieks to pitying heaven are cast,
When husbands or when lapdogs breathe their last!
Or when rich china vessels, fall'n from high,
In glittering dust and painted fragments lie!
"Let wreaths of triumph now my temples twine
(The victor cried), the glorious prize is mine!
While fish in streams, or birds delight in air,
Or in a coach-and-six the British fair,
While nymphs take treats, or assignations give,
So long my honor, name, and praise shall live!"

ATTICUS (ADDISON).

(From *The Prologue to the Satires.*)

Peace to all such! But were there one whose fires
True genius kindles, and fair fame inspires;
Blest with each talent and each art to please,
And born to write, converse, and live with ease;
Should such a man, too fond to rule alone,
Bear like the Turk no brother near the throne,
View him with scornful, yet with jealous eyes,
And hate for arts that caus'd himself to rise;
Damn with faint praise, assent with civil leer,
And without sneering teach the rest to sneer;
Willing to wound and yet afraid to strike,
Just hint a fault and hesitate dislike;
Alike reserv'd to blame, or to commend,
A timorous foe and a suspicious friend;
Dreading e'en fools, by flatterers besieg'd,
And so obliging, that he ne'er oblig'd;
Like Cato, give his little senate laws,
And sit attentive to his own applause;
While wits and templars every sentence raise,
And wonder with a foolish face of praise——
Who but must laugh, if such a man there be?
Who would not weep, if Atticus were he?

Gay and Prior.—Around Pope there were minor poets worthy of mention. Among them was good-natured John Gay (1688-1732). Pope describes him as

Of manners gentle, of affections mild,
In wit a man, simplicity a child.

He had been apprenticed to a tradesman, but turned to a literary career. He secured the patronage of a duchess, who treated him as a pet lapdog. He parodied Namby-Pamby Phillips's *Pastorals,* and in his *Trivia, or the Art of Walking in the Streets of London,* gives curious details of city life. His *Fables,* written in easy verse, hardly rival La Fontaine's French. His *Beggars' Opera* was a satire on the Italian Opera, recently introduced. It captivated the public and proved most remunerative to poet and manager.

Matthew Prior (1664-1721) was a man of more dignified position, a diplomat as well as a poet. He first attracted attention by a parody on Dryden's *Hind and Panther.* At first a Whig, he went over to the Tories, and when they lost power the poet was imprisoned for two years on a charge of high treason. He wrote in eight-syllable verse two long and thoughtful poems—*Alma* and *Solomon*—the former metaphysical, the latter scriptural. But he is better known by his love-songs and the ballad of *Henry and Emma.*

Edward Young (1681-1765) tried long to obtain a suitable position in public service. At the age of fifty he took orders and was made chaplain to George II. His first poetical work was a satire on *The Love of Fame the Universal Passion.* The next was *The Night Thoughts,* a long, solemn, blank-verse poem in nine books, containing meditations on life, death and immortality. Some of its epigrammatic sentences have become familiar proverbs, as "Procrastination is the thief of time."

The Rise of the English Novel.—To this period belong the first great English novelists. There had been, in Elizabeth's time, long romances, such as Sidney's *Arcadia* and short stories of adventure, but it remained for the eighteenth century to develop the use of fictitious narrative in prose to exhibit the passions, characters and incidents of real life, and connect them with a plot.

Daniel Defoe (1661-1731), if not the founder, was the harbinger of the English novel. The son of a London butcher, he was a busy tradesman, not always successful in business, but ever ready to advise other people. In numerous pamphlets he urged private and general reforms. A thorough-going Protestant, he was fined and imprisoned for his radical opinions. In *The True-born Englishman* he used rough rhyme to defend William of Orange and the Dutch against public prejudice. In *The Shortest Way with the Dissenters* he ironically proposed to hang their ministers and banish the people. The House of Commons condemned the pamphlet as a libel, and sentenced the author to stand in the pillory, but the people adorned it with flowers. He replied with an *Ode to the Pillory.* His *Review* added to the news political comments, and thus gave the hint for Steele's *Tatler.* In 1719 Defoe published the first part of *Robinson Crusoe,* getting the notion from Alexander Selkirk's sojourn on an island in the Pacific. The simple narrative of the shipwrecked voyager and his commencement of a new life on a remote island strongly impressed public imagination. The realistic character of the work brought it home to everyone. The same power of relating imaginary events so as to seem true was shown in *The Memoirs of a Cavalier* and *A Journal of the Great Plague in London.* In the latter the dreadful incidents are rendered terribly appalling. A remarkable variety of autobiographic fiction was poured forth. Its success was partly due to the fact that the stage had lost its hold on the public, while the number of readers was steadily increasing. Defoe was an active partisan journalist, and it is a strange fact that he was employed by the Government to answer in their organs the very articles that he was issuing anonymously in other newspapers.

Samuel Richardson.—Most historians give the credit of the invention of the modern novel to Samuel Richardson (1689-1761). He had been a printer's apprentice, became expert, was admitted to a partnership and eventually head of a prosperous business. He was a fluent letter-writer, and a London publisher, wishing to prepare a series of model letters for persons of little education, applied to him. He conceived the happy idea of connecting the letters by making them tell a story. The result was *Pamela, or Virtue Rewarded.* The heroine is a poor, innocent country girl taken into the service of a rich gentleman. She relates how she gradually discovered and steadily resisted the wicked designs of her master. This long-drawn-out romance of real life captivated the reading public of all classes. It became the fashionable topic and was gravely commended from the pulpit. Richardson was surprised to find himself famous, but he stuck to his business and eventually became printer to the king. Yet he also advanced steadily in the new path which he had broken. *Clarissa Harlowe* (1748) and *Sir Charles Grandison* (1753) had a popularity equal to that of his first venture. But while the author enjoyed the flattery of admiring friends, especially women, he was annoyed by the severe, unsparing criticism which the same works evoked. His *Letters* have been preserved and published, revealing the varied experience his sensitive nature had to undergo. *Clarissa Harlowe* is the tragical story of an innocent lady who falls a victim to the profligacy of the accomplished villain, Richard Lovelace. *Sir Charles Grandison* shows the ideal Christian gentleman, polished and virtuous. The reader of the present day finds these stories frightfully long, yet if he overcomes the reluctance to peruse them, he finds the mind gradually yielding to the almost irresistible attraction of the slow-moving narrative.

Henry Fielding.—In utter contrast to the sober, religious printer was the gay, extravagant bankrupt gentleman, Henry Fielding (1707-1754). Thrown on his own resources at the age of twenty, he wrote comedies for the stage and articles for the newspapers. He married a worthy wife and wasted her fortune in speculation. He studied law and failed at the bar. He published many political pamphlets. At last he made a great hit by his story of *Joseph Andrews* (1747), in which he ridiculed the timid morality and excessive sentimentalism of *Pamela.* In the latter story the lord whose vicious attempts were overcome by Pamela's firm virtue was called simply Lord B. Fielding represents Joseph Andrews as Pamela's brother, and Lord B.'s name is given in full as Booby. The most pleasing character is the eccentric Parson Adams, who combines learning, simplicity and courage in a whimsical way. The work has other well-drawn characters, and its tendency is more in behalf of virtue than might be expected. In *The Life of Jonathan Wild the Great* Fielding portrayed a determined scoundrel as if he fully admired him. But his masterpiece is the powerful story of *Tom Jones,* which comprises a series of surprising events leading to an inevitable catastrophe. In it ludicrous incidents are wonderfully combined with philosophic insight into character. Unfortunately, these are mingled with coarseness and vulgarity. Some of this he may have learned from the revelations of low life in his office as a police magistrate, but it seems to express his own inclination and delight. The story of *Amelia* was intended as an expression of repentance for the sins and follies, and as a tribute to his wife's virtue. His health had been broken by his labors and excesses, and he sailed to Lisbon for relief, but died there in a few months.

Fielding's stories have been highly relished by Englishmen as true pictures of the national life, with all its faults and eccentricities. Even so great a moralist as Dr. Johnson gave his warm approval to *Tom Jones.* All English critics conspire in uniform praise, excusing certain scenes as due to a low tone of morality now happily past, while Americans are astonished at much of its coarseness and vileness, as being unfit for decent readers.

Smollett.—The third of the great novelists of the eighteenth century was Tobias Smollett (1721-1771), a Scotchman who had studied medicine and served as a ship's surgeon. He early wrote poems and plays, but had his first success with the story of *Roderick Random* (1748), largely drawn from his own experience. Its popularity helped to establish the new form of fiction. Next came *Peregrine Pickle* (1751), full of hearty fun, then a free translation of *Don Quixote.* Smollett became editor of the *Critical Review,* compiled a big *History of England* and was sent to prison for libel. Here he wrote *The Adventures of Sir*

Lancelot Greaves, in imitation of *Don Quixote.* His last work, *The Expedition of Humphrey Clinker,* is his best. It depicts both English and Scotch characters with fidelity. He died while traveling in Italy. Smollett's stories abound in odd characters and laughable adventures, but are often too coarse for more modern readers.

Thomson.—The genius of Pope established the rhyming couplet as the standard form of English poetry for more than a century. Yet there were some who preferred and practiced other modes. None was more successful than the Scotch James Thomson (1700-1748). He was the son of a Presbyterian minister and was brought up in the beautiful valley of the Tweed. He early displayed poetic talent, but when he went to Edinburgh to study theology and versified a Psalm too freely he was warned that a minister should restrain his imagination if he wished to be useful. The poetic bent was too strong and the lad therefore went to London, where he was employed as a private tutor until he was able to bring out his first poem, *Winter,* in 1726. So great was the success of this fresh description of nature in her sterner mood that he was encouraged to go on to depict the other seasons. It is to Pope's credit that he showed no jealousy of this sturdy Scotchman, who carried his readers away from the closeness of cities and artificial life of courts to the broad expanse and sweeping breezes of the open country. Pope kindly lent his practiced hand in correcting some passages of the younger poet's first draught. The *Seasons* was published by subscription in 1730, and has ever since been a classic and favorite with lovers of genuine poetry. After traveling on the Continent, Thomson issued a new poem on *Liberty,* and by it obtained a pension of £100, after losing a sinecure court clerkship. He composed some tragedies which had moderate success. In the masque *Alfred* he was assisted by his friend and fellow-countryman, David Mallet. An ode from it has become the British national song—*Rule Britannia.* Thomson was appointed surveyor-general of the Leeward Islands, but was allowed to perform the duties by deputy, while he lived in a handsome retreat at the Kew Lane. Here he composed his last and most artistic production, *The Castle of Indolence,* in the Spenserian stanza. It was an allegory and the poet and his friends were depicted as inmates of the castle. A single stanza from this elegant poem will give a faint idea of its beauty:

I care not, Fortune, what you me deny,
  You cannot rob me of free Nature's grace.
You cannot shut the windows of the sky
  Through which Aurora shows her brightening face;
  You cannot bar my constant feet to trace
The woods and lawns by living streams at eve.
  Let health my nerves and finer fibres brace,
And I their toys to the great children leave;
Of fancy, reason, virtue, naught can me bereave.

In person Thomson was gross; in habit indolent; he was pampered with pensions, and yet his palpable faults may be forgiven for his original exquisite contributions to literature. He made the love and description of nature popular.

RULE BRITANNIA.

(From *Alfred, a Masque.*)

When Britain first, at Heaven's command,
  Arose from out the azure main,
This was the charter of the land,
  And guardian angels sang this strain:
    Rule, Britannia, rule the waves!
    Britons never will be slaves!

The nations not so blest as thee,
  Must in their turns to tyrants fall,
Whilst thou shalt flourish great and free,
  The dread and envy of them all.

Still more majestic shalt thou rise,
  More dreadful from each foreign stroke;
As the loud blast that tears the skies
  Serves but to root thy native oak.

Thee haughty tyrants ne'er shall tame;
  All their attempts to bend thee down
Will but arouse thy generous flame,
  But work their woe and thy renown.

To thee belongs the rural reign;
  Thy cities shall with commerce shine;
And thine shall be the subject main,
  And every shore it circles thine.

The Muses, still with freedom found,
  Shall to thy happy coast repair;
Blest isle, with matchless beauty crowned,
  And manly hearts to guard the fair!

CHAPTER VII.

Latter Half of the Eighteenth Century.

A. D. 1750—1800.

George II, who liked fighting and drinking better than books, continued to reign till 1760. But the middle of the century more exactly marks a change in English literature. In the first half the drama had steadily declined till it had ceased to be of any literary importance. In its place arose first the periodical essay, which continued to flourish throughout the entire century; and secondly the novel, which, after a promising outburst for a decade or more, strangely lingered and dwindled until reanimated in the nineteenth century by the potent genius of Sir Walter Scott.

George III was an honest, well-meaning, God-fearing man, earnestly trying to do his duty in the station in which God had placed him, to be an English king. He did not seek to be an absolute monarch, as did the Stuarts. He accepted the constitutional limitations as he understood them. But he wished to rule, to direct the course of affairs in his own way. It was not merely the action of Parliament, it was the stubborn insistence of the king that drove the American colonies into rebellion. The Declaration of Independence bristles with charges of wrong-doing and misrule by the king. It was hard for this sovereign, righteous in intention, to admit his course wrong in action. Yet he was compelled to do so, and to pay the penalty even to the loss of a large part of his dominions. In his private life he was a man of exemplary virtue, strictly religious, faithful to his wife, and he kept his court well regulated. He was economical, yet not penurious. He collected a fine library, which his son presented to the British Museum. The taste and example of this thorough, truth-loving Englishman had good effect upon the literature of his time. They tended to redeem it from the indecency into which it had fallen through evil influence from France.

Samuel Johnson.—The most prominent literary figure of this period was Dr. Samuel Johnson (1709-1784). By genuine merit, strenuous exertion and dogged perseverance, in spite of poverty, bodily infirmities, and proneness to melancholy, he rose to be the acknowledged sovereign of the literary world. His father was a poor bookseller at Lichfield, yet managed to send his bright son to Oxford. Though Samuel was prevented from graduating, he had become thoroughly imbued with classical learning. He married a wife much older than himself, and with the aid of a legacy took a large house and opened a school. Only three pupils came. In 1727, with one of these pupils, little David Garrick, he made his way to London. There he became a literary hack, doing all kinds of work, and contributing regularly to the *Gentleman's Magazine.* At that time it was against the law to report the debates in Parliament, but none the less it was done under feigned names in an imaginary kingdom. Johnson used his talent in this way, and being an ardent Tory, made sure that the Whig dogs got the worst of the contest.

Johnson's rising reputation was enhanced by his *London,* a poetical paraphrase of Juvenal's Satire on Rome. To this he afterwards joined another imitative poem on *The Vanity of Human Wishes.* As instances of disappointed ambition Johnson chose from modern history Wolsey and Charles XII, strikingly appropriate substitutes for Juvenal's Sejanus and Hannibal. In his days of want Johnson had been thrown in the company of Richard Savage, a man of talent despite his irregular habits and his unfounded pretences to noble birth. Full of sympathy for his misfortunes, Johnson wrote a pathetic biography of his comrade.

In 1747 Johnson undertook the preparation of his great *Dictionary of the English Language,* promising to complete it in three years. But though he labored arduously, the task required more than seven years. Heretofore dictionaries had contained merely explanations of hard words. Johnson made his work a storehouse of the actual usage of words, supporting his definitions by apposite quotations from standard authors. He endeavored to trace the historic development of each word, but he failed in the etymologies, because at that time the study of Early English or Anglo-Saxon was entirely neglected. Great, however, was the richly deserved success of his prodigious monumental work. The forty Immortals of the French Academy had spent forty years on a similar work for their native language. The courageous English scholar had beaten them on their own chosen field. The University of Oxford bestowed on her worthy son her highest honor in giving him the degree of LL.D. Other awards awaited the learned compiler. Posterity has crowned his fame. All later dictionaries, however enlarged and improved, are erected on the basis which Johnson laid.

The Fall of Patronage.—The polite Lord Chesterfield, who had neglected Johnson when in need, at last, when the work was approaching completion, offered to patronize it; but the sturdy doctor, in a spirited letter which has become famous, declined the nobleman's tardy recognition. In fact it was in this period that authors, as a rule, ceased to depend on the patronage of kings and noblemen for support and encouragement in their labors. Henceforth they turned for remuneration to the appreciative reading public. The periodical essay had contributed to bring about this change. Johnson, following the custom established by Steele and Addison, founded and carried on alone two periodicals, strangely named *The Rambler* and *The Idler.* But his dignified and weighty comments on human life are less acceptable than the light and graceful pleasantry of *The Spectator.*

It is his style in these that has been censured by critics; and the language, too heavily weighted with Latin derivatives, has been called "Johnsonese." The dauntless author, encumbered with his heavy armor, strove also to enter the domain of fiction in his *Rasselas*. But he gave little probability to the Abyssinian tale, which was rather a series of dialogues and reflections on moral and social topics than a recital of adventures or exhibition of characters.

When George III succeeded to the throne the English government began again to show favor to literature. Johnson, who had even in his definition of the word "pension" denounced the practice as pernicious, now being older and probably wiser, accepted a pension of £300. It was at this period that the Scotchman Boswell entered into the life that he was to enshrine for future generations. James Boswell (1740-1795) was, indeed, a vain and meddlesome coxcomb, but he had the wit to perceive the high value of Johnson's conversation, and the faculty of so recording it, with its accessories, as to transmit to posterity a life-like portrait of the sage and an admirable picture of the brilliant society gathered around him. In 1773 Boswell induced his revered doctor to make a journey with him to the Hebrides, then as remote as South Africa is to-day. Both travelers have given narratives of the expedition, and it is interesting to compare their versions; but it is even more instructive to examine Johnson's original letters to Mrs. Thrale, on which his published work was founded, and observe the transformation from the familiar style to the more pompous. Mrs. Thrale was the wife of a wealthy brewer, and took delight in intellectual society. In company with them Johnson visited Paris and various parts of England.

Johnson's last important work was his *Lives of the Poets* (1781). He had been requested to write a preface for a new edition of the English poets and a brief biographical sketch of each. But the sketches expanded into a volume, much of which is now considered his best prose writing. As a critical work it is of unequal merit. Johnson, swayed by his prejudices, disparaged Milton and Thomson, and gave unstinted praise to Pope and Cowley. After suffering for two years from dropsy, Johnson died in December, 1784. He was buried in Westminster Abbey.

Dr. Johnson was the representative man of letters of his period. From the humblest beginning, as a bookseller's hack, he had slowly forced his way to be the "Great Cham" of the literary world of London. He retained to the last many marks of his low origin. He was dirty, slovenly, scarred with small-pox, ill-mannered, and yet on occasions he spoke and acted with great dignity. He was short-sighted and afflicted with some twitching nervous disease. But he was resolute, independent and outspoken. He was deeply religious, and enforced respect for religion even on scoffers. He was truly generous, and after the death of his wife maintained a curious household of needy dependents. He is better known by Boswell's biography than by his own writings.

CARDINAL WOLSEY.

(From *The Vanity of Human Wishes.*)

In full-blown dignity, see Wolsey stand,
Law in his voice, and fortune in his hand:
To him the church, the realm, their powers consign;
Through him the rays of regal bounty shine;
Turned by his nod the stream of honor flows,
His smile alone security bestows:
Still to new heights his restless wishes tower;
Claim leads to claim, and power advances power;
Till conquest unresisted ceased to please,
And rights submitted left him none to seize.
At length his sovereign frowns—the train of state
Mark the keen glance, and watch the sign to hate:
Where'er he turns he meets a stranger's eye,
His suppliants scorn him, and his followers fly;
Now drops at once the pride of awful state,
The golden canopy, the glittering plate,
The regal palace, the luxurious board,
The liveried army and the menial horde.
With age, with cares, with maladies oppressed,
He seeks the refuge of monastic rest.
Grief aids disease, remembered folly stings,
And his last sighs reproach the faith of kings.
Speak thou, whose thoughts at humble peace repine,
Shall Wolsey's wealth, with Wolsey's end, be thine?
Or liv'st thou now, with safer pride content,
The wisest justice on the banks of Trent?
For why did Wolsey, near the steeps of fate,
On weak foundations raise the enormous weight!
Why, but to sink beneath misfortune's blow,
With louder ruin to the gulfs below.

VENAL PRAISE.

(From *The Rambler.*)

No man can observe without indignation on what names, both of ancient and modern times, the utmost exuberance of praise has been lavished, and by what hands it has been bestowed. It has never yet been found that the tyrant, the plunderer, the oppressor, the most hateful of the hateful, the most profligate of the profligate, have been denied any celebrations which they were willing to purchase; or that wickedness and folly have not found correspondent flatterers through all their subordinations, except when they have been associated with avarice and poverty, and have wanted either inclination or ability to hire a panegyrist. As there is no character so deformed as to fright away from it the prostitutes of praise, there is no degree of encomiastic veneration which pride has refused. The emperors of Rome suffered themselves to be worshiped in their lives with altars and sacrifices; and in an age more enlightened the terms peculiar to the praise and worship of the Supreme Being have been applied to wretches whom it was the reproach of humanity to number among men; and whom nothing but riches or power hindered those that read or wrote their deification from hunting into the toils of justice as disturbers of the peace of nature.

DR. JOHNSON'S LETTER TO THE EARL OF CHESTERFIELD.

February 7, 1755.

My Lord: I have been lately informed, by the proprietor of "The World," that two papers, in which my Dictionary is recommended to the public, were written by your lordship. To be so distinguished is an honor, which, being very little accustomed to favors from the great, I know not well how to receive, or in what terms to acknowledge.

When, upon some slight encouragement, I first visited your lordship, I was overpowered, like the rest of mankind, by the enchantment of your address, and could not forbear to wish that I might boast myself *Le vainqueur du vainqueur de la terre*—that I might obtain that regard for which I saw the world contending; but I found my attendance so little encouraged, that neither pride nor modesty would suffer me to continue it. When I had once addressed your lordship in public, I had exhausted all the art of pleasing which a retired and uncourtly scholar can possess. I had done all that I could; and no man is well pleased to have his all neglected, be it ever so little.

Seven years, my lord, have now past, since I waited in your outward rooms, or was repulsed from your door; during which time I have been pushing on my work through difficulties, of which it is useless to complain, and have brought it, at last, to the verge of publication, without one act of assistance, one word of encouragement, or one smile of favor. Such treatment I did not expect, for I never had a patron before.

The shepherd in Virgil grew at least acquainted with Love, and found him a native of the rocks.

Is not a patron, my lord, one who looks with unconcern on a man struggling for life in the water, and, when he has reached ground, encumbers him with help? The notice which you have been pleased to take of my labors, had it been early, had been kind; but it has been delayed till I am indifferent, and cannot enjoy it; till I am solitary, and cannot impart it; till I am known, and do not want it. I hope it is no very cynical asperity not to confess obligations where no benefit has been received, or to be unwilling that the public should consider me as owing that to a patron, which Providence has enabled me to do for myself.

Having carried on my work thus far with so little obligation to any favorer of learning, I shall not be disappointed though I should conclude it, if less be possible, with less; for I have been long wakened from that dream of hope, in which I once boasted myself with so much exultation, my lord,

Your lordship's most humble,
most obedient servant,
Sam. Johnson.

The Literary Club.—About 1760 Dr. Johnson, Sir Joshua Reynolds, Edmund Burke and some others formed a club, which held weekly meetings for friendly discussion at various places. The club consisted of choice spirits, and became famous as a promoter of literature. Edmund Burke (1730-1797), one of its founders, was born in the south of Ireland, but went to England and engaged in literary work. His first essay was an ironical imitation of Lord Bolingbroke's views and style. Published anonymously, it was called *The Vindication of Natural Society* (1756), and was at first accepted by many as a posthumous work of the philosophic nobleman. Burke's next treatise was *An Inquiry into the Origin of Our Ideas of the Sublime and Beautiful* (1756), which has long been a text-book on æsthetics. His excellent *Account of the European Settlements in America* (1757) is not usually included in editions of his works. He also conducted the *Annual Register,* begun in 1759.

With genius for statesmanship, Burke entered into politics in 1765 under the patronage of the Marquis of Rockingham, then prime minister. His eloquent speeches in Parliament in behalf of the American colonists before and during the Revolution are still admired and studied for their political wisdom. But when the French Revolution broke out, he became alarmed for the safety of society and endeavored to restrain the dangerous tendencies of the age. His masterly *Reflections on the French Revolutior* (1790) showed that he had left the Whig party. After a few years of struggle he retired from Parliament in 1794. Attacks were made upon him by his former friends for accepting liberal pensions, but he successfully defended himself in his *Letter to a Noble Lord* (1795). His last publication, *Two Letters on the Proposal for a Regicide Peace*, showed that he had lost none of his original power. It inspired the English people with the courage necessary to maintain a long, bloody and expensive war. In the interval between the American and the French Revolutions Burke had been the foremost prosecutor of Warren Hastings for maladministration in India and oppression of the native rulers. His speech in presenting to the House of Lords the articles of impeachment against the Governor-General is regarded as his crowning glory. The trial, however, was unduly prolonged for eight years, and Hastings escaped conviction. Burke's writings, though largely political, are valuable contributions to English literature. He has been pronounced by Lord Macaulay to have excelled every other orator, ancient or modern, in aptitude of comprehension and richness of imagination.

Another noted member of Johnson's club was the pupil who had accompanied him to London and had become the greatest actor of his time. David Garrick (1716-1779) endeavored to redeem the theatre from its degradation by banishing indecency and restoring natural acting. Dr. Johnson wrote the prologue for the opening of his theatre in 1747, and the manager afterward brought out his friend's *Irene* with success. He gave new life to the plays of Shakespeare, and in 1769 conducted a Shakespeare Jubilee at Stratford-on-Avon, which he afterward repeated for nearly a hundred nights in London.

Goldsmith.—Perhaps no writer of the eighteenth century was more versatile or more uniformly successful in his literary endeavors than Oliver Goldsmith (1728-1774). Born at Pallas, in Ireland, the son of a poor curate with a large family, he was befriended by relatives so that he could attend the Dublin University. But the careless, good-natured fellow profited little by his opportunities. After some vain attempts at the study of theology, law and medicine, varied by school teaching, he wandered over France and Italy, often getting food and lodging by playing on his flute to dancing villagers. His degree of M.D. is said to have been obtained at Leyden, but he never practiced the profession. Instead he was a shop-clerk or usher at a school until he obtained employment from the publishers. His first book of importance was *The Present State of Polite Learning in Europe* (1759), which attracted the attention of the learned class. For a newspaper he wrote a series of *Chinese Letters,* which were afterwards gathered in a volume under the title, *Letters from a Citizen of the World.* In them he assumed the character of an observant Chinese merchant traveling in England and describing the manners and customs of the people. For the booksellers the ready-witted Irishman wrote anything they wished, children's story-books, school histories, translations, prefaces, indexes.

But Goldsmith was gifted for better work. His first published poem, *The Traveler* (1764), described the scenes on the Continent, through which he had recently passed. Whatever recompense was received for his labor was soon squandered. Once, when hard pressed by debt, he appealed to the benevolence of Dr. Johnson, who found he had just written *The Vicar of Wakefield.* After reading some of the manuscript the doctor relieved his immediate wants and recommended the story to his publisher. This well-known picture of English country life is the best production of its time and sort. The Rev. Dr. Primrose, strong in Christian faith and honor, maintains his virtue amid crushing misfortunes, so that even in jail he preaches to his fellow-prisoners, and fearlessly beholds the approach of death, and when restored to worldly happiness preserves his humility. His more ambitious wife, son and daughters are depicted with such alternate humor and pathos that while we smile at their droll adventures, or sympathize in their misfortunes, we recognize the author's fidelity to human nature. The plot of the story is not without improbabilities, but the successive scenes are vivid pictures of the conditions of that period. Yet so doubtful was the publisher of its success that after paying for the manuscript he held it back for two years, till the publication of *The Traveler* had made the author known. Every English reader is familiar with Goldsmith's later poem, *The Deserted Village* (1770), that charming idealized description of Lissoy, where his boyhood was spent. Pope's rhyming couplet is here used to enshrine exquisite pictures of rural life and manners.

With Garrick for a friend, Goldsmith also contributed to the stage two comedies, which are still favorites—*The Good-Natured Man* and *She Stoops to Conquer.* The former is a comedy of character, the latter of intrigue. In the former Croaker furnishes abundant amusement, and the finest scene is where the disguised bailiffs who have arrested Honeywood and levied on his goods are passed off on Miss Richland as friendly visitors. In the second comedy the interest depends on the farcical incidents which follow the mistaking of a country residence for an inn. Goldsmith's admirable humor was again displayed in the short poem, *The Haunch of Venison,* in which he describes how the very acceptable present for his table was in danger of being devoured by some unwelcome guests.

Goldsmith's pecuniary embarrassments and irregularities in private life never deprived him of the affection of his literary associates. His fellow-members in Johnson's club seem to have treated him both as a pet and a butt. On one occasion when he did not appear at the stated hour of meeting, after speaking of him as "the late Dr. Goldsmith," they went on to compose appropriate epitaphs. Only that suggested by Garrick is extant:

"Here lies Oliver Goldsmith, for shortness called Noll;
Who wrote like an angel, and talked like poor Poll."

Goldsmith took the joke good-naturedly, and afterwards retorted on Garrick:

"Our Garrick's a salad, for in him we see
Oil, vinegar, sugar and saltness agree."

But this couplet is only a small part of his clever *Retaliation,* which he left incomplete.

To this worthy man of letters a cenotaph was erected in Westminster Abbey, and for it Dr. Johnson composed an admirable epitaph in stately Latin, part of which may be rendered in homely English thus:

"He left scarcely any kind of writing untouched, and touched nothing that he did not adorn. Of all the passions (whether smiles were to be moved or tears) he was a powerful yet gentle master; in genius sublime, vivid, versatile; in style elevated, clear, elegant. The love of companions, the fidelity of friends, and the veneration of readers, have honored his memory by this monument."

THE VILLAGE PASTOR.

(From *The Deserted Village.*)

Near yonder copse, where once the garden smiled
And still where many a garden flower grows wild,
There, where a few torn shrubs the place disclose,
The village preacher's modest mansion rose.
A man he was to all the country dear,
And passing rich with forty pounds a year;
Remote from towns he ran his godly race,
Nor e'er had changed, nor wished to change his place,
Unskillful he to fawn, or seek for power
By doctrines fashioned to the varying hour;
Far other aims his heart has learned to prize—
More bent to raise the wicked than to rise.
His house was known to all the vagrant train,
He chid their wanderings, but relieved their pain.
Pleased with his guests the good man learned to glow,
And quite forgot their vices in their woe;
Careless their merits or their faults to scan,
His pity gave ere charity began.
Thus to relieve the wretched was his pride,
And e'en his failings leaned to virtue's side.
But in his duty prompt at every call,
He watched and wept, he prayed and felt for all;
And as a bird each fond endearment tries
To tempt its new-fledged offspring to the skies,
He tried each art, reproved each dull delay,
Allured to brighter worlds and led the way.
Beside the bed where parting life was laid,
And sorrow, guilt, and pain by turns dismayed,
The reverend champion stood. At his control
Despair and anguish fled the struggling soul;
Comfort came down the trembling wretch to raise,
And his last faltering accents whispered praise.
At church, with meek and unaffected grace,
His looks adorned the venerable place;
Truth from his lips prevailed with double sway,
And fools who came to scoff remained to pray.
The service past, around the pious man,
With ready zeal each honest rustic ran;
E'en children followed with endearing wile,
And plucked his gown to share the good man's smile.
His ready smile a parent's joy exprest,
Their welfare pleased him, and their cares distrest;
To them his heart, his love, his griefs were given,
But all his serious thoughts had rest in heaven.
As some tall cliff that lifts its awful form,
Swells from the vale and midway leaves the storm,
Though round its breast the rolling clouds are spread,
Eternal sunshine settles on its head.

EPITAPH FOR EDMUND BURKE.

(From *The Retaliation.*)

Here lies our good Edmund, whose genius was such,
We scarcely can praise it or blame it too much;
Who, born for the universe, narrowed his mind,
And to party gave up what was meant for mankind;
Though fraught with all learning, yet straining his throat
To persuade Tommy Townshend to lend him a vote;
Who, too deep for his hearers, still went on refining,
And thought of convincing while they thought of dining;
Though equal to all things, for all things unfit;
Too nice for a statesman, too proud for a wit;
For a patriot too cool, for a drudge disobedient,
And too fond of the right to pursue the expedient:
In short, 'twas his fate, unemployed, or in place, sir,
To eat mutton cold, and cut blocks with a razor.

Thomas Gray.—There was another poet of that time more learned but less copious, one of whose poems is equally familiar with Goldsmith's best. This was Thomas Gray (1716-1771). He was educated at Eton College and Cambridge University, where he was made a Fellow and professor of history. Well versed in the ancient classics, he studied also the Romance literature of the Middle Ages, and the long neglected Scandinavian and Celtic poetry. His beautiful *Ode on a Distant Prospect of Eton College* (1747) gave him a reputation as a poet. But this was far surpassed by his famous *Elegy Written in a Country Churchyard.* Its thoughts appeal to the minds of all, but they are expressed with such grace and dignity and illustrated with such impressive allusions that they form a perfect work of art. Gray's elaborate *Pindaric Odes* have also enriched the English language. The finest is *The Bard,* which represents a Welsh poet, who, barely escaping slaughter, deplores the ruthless invasion of his country by Edward I and is inspired to perceive and foretell the movement of English history for centuries to come. Such vehemence of passion seems strange when coming from the quiet cloisters of an English college in the middle of the eighteenth century. Perhaps the recent invasion of the Young Pretender gave the needful stimulus to the scholarly poet's imagination. Equally artistic are his *Progress of Poesy* and *Hymn to Adversity.* In *The Descent of Odin* Gray utilized his knowledge of the old Norse legends. Every student of Gray's exquisite poetry laments that he was content rather to file and polish a few gems than to pour forth abundantly from his richly-stored mind.

ODE ON A DISTANT PROSPECT OF ETON COLLEGE.

Ye distant spires, ye antique towers,
  That crown the watery glade,
Where grateful Science still adores
  Her Henry's holy shade!
And ye, that from the stately brow
Of Windsor's heights the expanse below
  Of grove, of lawn, of mead survey,
Whose turf, whose shade, whose flowers among
Wanders the hoary Thames along
  Her silver-winding way!

Ah, happy hills! ah, pleasing shade!
  Ah, fields beloved in vain!
Where once my careless childhood strayed,
  A stranger yet to pain!
I feel the gales that from ye blow
A momentary bliss bestow,
  As waving fresh their gladsome wing,
My weary soul they seem to soothe,
And, redolent of joy and youth,
  To breathe a second spring.

Say, Father Thames, for thou hast seen
  Full many a sprightly race,
Disporting on thy margent green,
  The paths of pleasure trace,
Who foremost now delight to cleave
With pliant arm thy glassy wave?
  The captive linnet which inthral?
What idle progeny succeed
To chase the rolling circle's speed,
  Or urge the flying ball?

While some on earnest business bent
  Their murmuring labors ply
'Gainst graver hours, that bring constraint
  To sweeten liberty;
Some bold adventurers disdain
The limits of their little reign,
  And unknown regions dare descry:
Still as they run they look behind;
They hear a voice in every wind,
  And snatch a fearful joy.

Gay hope is theirs, by fancy fed,
  Less pleasing when possessed;
The tear forgot as soon as shed,
  The sunshine of the breast.
Theirs buxom health of rosy hue,
Wild wit, invention ever new,
  And lively cheer of vigor born;
The thoughtless day, the easy night,
The spirits pure, the slumbers light,
  That fly the approach of morn.

Alas! regardless of their doom,
  The little victims play;
No sense have they of ills to come,
  Nor care beyond to-day;
Yet see how all around them wait
The ministers of human fate,
  And black Misfortune's baleful train!
And show them where in ambush stand,
To seize their prey, the murd'rous band;
  Ah, tell them they are men!

* * * * * * *

To each his sufferings: all are men,
  Condemned alike to groan;
The tender for another's pain,
  The unfeeling for his own.
Yet, ah! why should they know their fate?
Since sorrow never comes too late,
  And happiness too swiftly flies.
Thought would destroy their paradise.
No more:—where ignorance is bliss,
  'Tis folly to be wise.

William Collins (1720-1756) was also a skilful writer of odes. He was educated at Winchester College and Oxford University. Full of ambitious literary projects he left Oxford abruptly and went to London only to be disappointed. He fell into dissolute habits, squandered his means and became insane. His *Persian Eclogues* have been long forgotten. His most ambitious work, the *Ode on the Passions* (1746), is now less esteemed than formerly, because of the growing dislike for allegorical treatment. But his shorter odes are regarded among the best in the language, especially the nameless dozen lines written in 1746.

How sleep the brave, who sink to rest
By all their country's wishes blest?
When Spring, with dewy fingers cold,
Returns to deck their hallow'd mould,
She there shall dress a sweeter sod
Than Fancy's feet have ever trod.

By fairy hands their knell is rung;
By forms unseen their dirge is sung;
There Honor comes, a pilgrim gray,
To bless the turf that wraps their clay;
And Freedom shall a while repair,
To dwell a weeping hermit there!

James Beattie.—Few poets have been more amply rewarded for their work than the Scotch Doctor James Beattie (1735-1803). The son of a farmer, he had taught a village school before he reached a professor's chair in Marischal College, Aberdeen. In 1771 he published the first part of *The Minstrel*, a romantic descriptive poem in the Spenserian stanza. Enthusiastically welcomed by the people, it won for the author a pension of £200 from King George III, and the degree of LL.D. from Oxford. This was in striking contrast with its opening lines:

Ah! who can tell how hard it is to climb
The steep where Fame's proud temple shines afar?

The hero of the poem is the young minstrel Edwin, who is directed by a hermit in his search for beauty and truth. Beattie wrote also many prose dissertations and vigorously opposed Hume's skeptical philosophy.

Percy's Reliques.—A memorable event in literature was the publication of Percy's *Reliques of Ancient English Poetry* in 1765. It revived acquaintance with old ballads which had long been forgotten and gave a fresh start to poetic genius. Thomas Percy (1729-1811), though he claimed kindred with the Duke of Northumberland, was of humble origin. He graduated at Oxford, and entered the Church, became Dean of Carlisle, and finally Bishop of Dromore, in Ireland. In a folio manuscript, written early in the seventeenth century, he found a large number of old ballads of the North of England, and afterward collected more. When publishing these he sought to improve them according to the taste of his time. Yet much of the original flavor was retained, and they became precious models for Walter Scott and other youths of genius. Percy's alterations of the original text were severely censured by the snarling antiquary Joseph Ritson, who published more correct versions of such ballads as he could find. But his exactness in following copy was little appreciated at the time. Not until late in the nineteenth century did the zeal for exact quotation find expression in the admirable publications of the Early English Text Society, edited by Dr. F. J. Furnivall. A century was required for the full fruit of Percy's publication to be manifested in the recovery of old literature and the production of new poems in the old spirit.

Another writer who aided in directing attention to the older poets was Thomas Warton (1728-1790). He was professor of poetry at Oxford, and before he obtained this position had published critical *Observations on the Faerie Queene;* afterward his more valuable *History of English Poetry* in two volumes, which, however, brought the account only to the reign of Elizabeth. Warton was made poet laureate in 1785. He was a faithful critic and a diligent historian rather than an inspired poet.

Macpherson's Ossian.—A veritable sensation was caused in this period by the publication of *Fragments of Ancient Poetry Translated from the Gaelic or Erse Language* (1760). The editor was James Macpherson (1738-1796), a Scotchman who had been educated for the ministry, and began to collect these fragments in the Highlands. With such favor were they received that he was enabled by subscription to travel in search of more. As a result he published *Fingal* (1762), an epic in six books, and then *Temora* (1763). The poems were ascribed to Ossian, said to be a Scotch or Irish poet of the third century. The translation published was in a peculiar style of poetic prose, which won favor not merely in Britain but on the Continent. But many were incredulous about the professed origin of these writings and among them was Dr. Johnson, who boldly denounced Macpherson as a forger. A heated controversy ensued, but the truth seems to be that Macpherson had at first translated some fragments and then found it less labor to compose more in similar style, and sell them for genuine antiques.

Chatterton.—The precocious genius and melancholy career of Thomas Chatterton (1752-1770) form a sad episode in this period. The son of a sexton in Bristol, the boy found in a church a chest containing old charters and documents. Becoming familiar with their antiquated style, he began to forge papers which should be of interest to wealthy citizens, pedigrees and notices of local events. Then he went on to compose poems, which he attributed to the monk Rowley. The poems were good, but the spelling was bad, such as was never used before. Full of ambition the lad started for London, where he hoped to find a better field for his strange work. After a brief severe struggle with sore disappointment he poisoned himself. His poetical merit has been acknowledged by Wordsworth and others of the highest authority.

Hume.—Three great historians stand prominent in the literature in the eighteenth century. Two of them, indeed, were Scotchmen, yet their works are an important part of the literary glory of the English language. Their histories differed from previous attempts in being philosophical in treatment of events. They endeavored to trace the hidden causes of the political movements which they related, and succeeded so admirably that, in spite of the immense labor of research which has since been accomplished in the same fields, their works have not yet been entirely superseded.

David Hume (1711-1776) was naturally more inclined to metaphysics than history, and published some treatises of that sort before he engaged in the *History of England.* But he had been secretary in various embassies on the Continent, and thus had opportunity to learn the elements of statesmanship. In 1752 he was appointed librarian to the Faculty of Advocates in Edinburgh, and utilized its materials for his history of the Stuart dynasty. Greatly to the dismay of the philosophic author, when it began to appear all parties joined in outcries against its defense of the first Stuart kings, and few copies were sold. Not until this section was completed was any favor shown to the work. Then Hume added the reigns of the Tudor dynasty, and obtained more favor. At last, in 1761, he prefixed the history from the earliest times. When it was complete the work became remarkably popular. Hume was a decided Tory and earnestly upheld the royal prerogative. He did not spend time in original research as later historians are compelled to do. In his day the national archives were hardly accessible. His narrative is clear and well arranged; his style has been charged with being French rather than English in structure. The acute Scotchman was indeed strongly imbued with French ideas in every department of thought, and his works thus encountered strong national prejudices. Yet his history, in spite of faults of style and statement, remains a noble monument to his persevering industry.

Robertson.—The second of the great trio of historians was also a Scotchman, but widely separated from Hume in religious and philosophical belief. William Robertson (1721-1793) was a leading divine in the Church of Scotland, the principal of its Theological Seminary in Edinburgh. He was an eloquent preacher and the head of the ecclesiastical party called Moderates, who aimed more at liberal culture than doctrinal orthodoxy. His first work to attract general attention was a *History of Scotland* (1759), treating chiefly of the reigns of Queen Mary and her son until he became King of England. The Presbyterian divine showed strong sympathy for the beautiful and unfortunate Queen. As a reward for his labors he was appointed royal historiographer for Scotland. He went on and published a *History of Charles V,* which showed the same desire for judicial fairness to characters from whom he differed most widely in belief. The work has been edited by the American, W. H. Prescott, who undoubtedly made it his model in his original works. Robertson in his introduction gave a valuable survey of Europe in the Middle Ages. His excellence is seen in such general philosophical dissertations. His last great work was a *History of America,* which began to appear in 1778, but was not concluded till 1796, the last two volumes being issued by his son. Although, in the main, this work has been superseded by the labors of later historians, it deserves high praise for its initiative effort. Robertson was not acquainted with the researches of German and Spanish investigators, and yet John Fiske in his *Discovery of America* has acknowledged his predecessor's surprising accuracy and philosophic insight. All of Robertson's works are characterized by a grand, yet fluent, style, but somewhat deficient in animation.

Gibbon.—Last in order but greatest in merit comes the English historian of Rome, who more than the others anticipated the thoroughness of research which characterizes the new historical method. Edward Gibbon (1737-1794) was born near London, and attended Oxford University for a year. Then, on account of his embracing the Catholic faith, his father sent him to Switzerland, where his studies were directed by a Protestant pastor. Here he commenced a course of systematic study and became thoroughly imbued with French ideas. His first work, *The Study of Literature,* was written in French. Gibbon wished to marry his teacher's fair daughter, but his father again interfered. The historian in his *Memoirs* thus tells the result: "I sighed as a lover, and obeyed as a son." He then traveled over France and Italy. Here his plan of his lifework was formed. To use his own words again: "As I sat musing amidst the ruin of the Capitol, while the barefooted friars were singing vespers in the Temple of Jupiter, the idea of writing the Decline and Fall of the city first started to my mind." Yet some years elapsed before he set himself fairly to the work. He returned to England, took up the usual life of a country gentleman, and entered Parliament, where he supported the Tory administration. The first volume of *The Decline and Fall of the Roman Empire* appeared in 1776, and won popular favor as well as the approval of the learned. The only dissent was on account of its treatment of the rise of Christianity to world power. As years passed new volumes were added, until the magnificent work was completed in 1787. He was already assured of permanent fame. His history extends from the reign of Trajan to the fall of Constantinople in 1453, thus comprising more than thirteen centuries. It treats of the slow decline of Roman grandeur, the irruption of the Asiatic barbarians, the establishment of the Byzantine empire, the rise of new governments, the rapid spread of Mohammedanism and the vicissitudes of the Crusades. Such an immense task required familiarity with philosophy, theology, science, jurisprudence and war, as they contributed to the overthrow of one system of civilization and the establishment of another. Yet all this was accomplished, and the results were presented in a masterly style. Although his skepticism as to the Christian religion was manifest throughout, Gibbon did not intentionally distort facts or misquote his authorities. Yet he was bitterly assailed on this charge, and the distrust still lingers. The elaborate *Vindication,* in which he refutes his opponents, has been approved by Guizot and Milman, who have vouched for his accuracy and annotated his work. Like his contemporary historians Gibbon has been criticised for using a French or Latinized style. Yet his stately sentences appear not inappropriate to his grand theme. A serious fault is that his imagination was sensuous and led him to give prominence to material grandeur rather than moral elevation. There is also a proneness to admit slyly into his notes the sensual ideas of a decaying civilization. Later writers who have treated more fully various periods included in his monumental work have accorded it the highest praise for historical worth.

Laurence Sterne.—Every age has its eccentric characters, men who are notable and much looked after and talked about, yet whom it is difficult to describe and impossible to classify. Such a writer was the Rev. Laurence Sterne (1713-1768). He was born at Clonmel, Ireland, the son of an army officer who was stationed there. The father afterward died at Gibraltar of a wound received in a duel. The mother had influential relatives, by whose aid Laurence was sent to Cambridge University. Here he was rather an omnivorous reader than a hard student. Taking orders, he had charge of a church in Yorkshire, and later was also connected with York Cathedral. Though he was selfish and careless in his habits, he preached good, moralizing sermons, some of which seemed aimed at his own faults. They were published under the assumed name Yorick. But his fame began with the publication of the first part of the whimsical *Tristram Shandy* in 1757. In this rambling, desultory book, which pretends to be an autobiography, the person who bears its name hardly appears, but there are other characters who have become noted. Mr. Shandy, Tristram's father, is a controversial country gentleman; opposed to him is Dr. Slop, a Roman Catholic physician, while Yorick, the parson (representing Sterne himself), is lukewarm. But the chief characters are Uncle Toby, who has been at the wars in Flanders, and his faithful servant, Corporal Trim. Uncle Toby keeps up a show of military habits, has a fortification in his garden, with sentry box and cannon. In the sentry box the gallant Uncle Toby narrowly escaped surrendering to his charming, strategical neighbor, Widow Wadman. There is little of real story, but an endless number of digressions and discussions on all sorts of subjects. Many of the striking passages and learned quotations are now known to be plagiarized from Burton and Rabelais. But for the time they gave Sterne entrance to smart society in London and afterward in Paris. From his travels in France and Italy Sterne gathered material for a new work, *The Sentimental Journey,* which he intended to be a continuation of *Tristram Shandy,* with new scenery. It has similar pathetic passages and pretense of learning, and like the former work is streaked and tainted with licentiousness. Honest Goldsmith called the author "the blackguard parson." Sterne did not retain the crowd of admirers who had hovered about him for a while. Taken ill at his fashionable lodgings in London, he died almost unattended. His works still supply fine passages to anthologies, but are otherwise little read. "He was a jester, rather than a humorist," says Thackeray.

William Cowper.—Before the end of the eighteenth century there were many signs of transition in English literature. Pope had so corrected and polished the rhyming couplet that the common herd of poets aimed only to reproduce it, and often sacrificed sense to sound. But the men of genius, while accepting the standard in some of their works, took liberty to try new meters or revive old ones. They turned away from the trivialities of artificial life and found inspiration in the beauties of nature. Thomson and Gray had done this with marked success, and late in life the gentle William Cowper (1731-1800) was emboldened to compose verses.

Cowper was the son of a clergyman who had been chaplain to George II. He was educated at Westminster School and studied law, but a nervous melancholy drove him into retirement. He became actually insane and attempted suicide. He was tenderly cared for by pious Mrs. Unwin. In company with Rev. John Newton he published the *Olney Hymns* (1771), expressing the evangelical views of religion. Later, at the suggestion of Mrs. Unwin, he undertook secular poetic composition. In this he found health, and published the *Progress of Error,* and a didactic series on *Truth, Hope and Charity* in 1782.

Hitherto all of Cowper's compositions had been serious and duly rhymed in couplets, but when the lively Lady Austin diverted the melancholy poet with the story of John Gilpin's Ride he turned it into a playful ballad. The Lady, delighted, now advised him to try blank verse. "Set me a subject, then," said he. "Oh, you can write on anything. Take the sofa." So Cowper began the best of his poems, calling it *The Task*. It is by no means confined to the sofa; it shows the progress of human invention, starting from the humble stool, advancing to the more restful chair, the spacious bench, and at length the luxurious sofa and the many comforts of his secluded home. Then, turning to the routine of his daily life, it ventures out of doors, describes the garden, his pet hares, his friends, the summer and the winter walk, the landscape about Olney, and from these takes flight even as far as the Czarina's ice palace, and ends with a prophecy of the Kingdom of God. Altogether it comprises six books. Artificial as it is in form and subject, it is true throughout to English nature, and has ever been enjoyed by persons of domestic taste. Before this poem was published, in 1785, Cowper, to preserve his health, had taken up another task—the translation of Homer. Being justly dissatisfied with Pope's rendering in rhyme, he used blank verse as the appropriate English measure for an epic. The result was more true to the spirit of the original, yet by no means up to Milton's perfect performance. Matthew Arnold has ably discussed the matter in his essays *On Translating Homer,* and favors the use of the dactylic hexameter. Bryant, in his old age, attempted the work again, using blank verse, of which he had shown surprising mastery in early youth. After the Homer was published, in 1791, Cowper suffered a relapse, and was able to do little work except revise his publications.

One of Cowper's most touching poems is *Lines on Receiving My Mother's Picture;* another is *Lines Supposed to be Written by Alexander Selkirk,* the marooned sailor, whose experience suggested to De Foe the story of *Robinson Crusoe;* still another is his lament for *The Loss of the Royal George.*

Cowper carried on the poetical description of Nature, begun by Thomson. His treatment of it is full of that genuine love which afterward characterized Wordsworth. He also showed affection for mankind in general, and hence introduced into his work social questions, philanthropic endeavors, universal freedom, international union, and the progress of humanity. These were discussed, however, without strong passion, but rather in a calm, philosophic spirit.

THE GIPSIES.

(From *The Task*, Book I.)

I see a column of slow-rising smoke
O'ertop the lofty wood that skirts the wild.
A vagabond and useless tribe there eat
Their miserable meal. A kettle, slung
Between two poles upon a stick transverse,
Receives the morsel; flesh obscene of dog,
Or vermin, or, at best, of cock purloined
From his accustomed perch. Hard-faring race!
They pick their fuel out of every hedge,
Which, kindled with dry leaves, just saves unquenched
The spark of life. The sportive wind blows wide
Their fluttering rags, and shows a tawny skin,
The vellum of the pedigree they claim.
Great skill have they in palmistry, and more
To conjure clean away the gold they touch,
Conveying worthless dross into its place;
Loud when they beg, dumb only when they steal.
Strange! that a creature rational, and cast
In human mould, should brutalize by choice
His nature, and, though capable of arts
By which the world might profit and himself,
Self-banished from society, prefer
Such squalid sloth to honorable toil!
Yet even these, though, feigning sickness oft,
They swathe the forehead, drag the limping limb,
And vex their flesh with artificial sores,
Can change their whine into a mirthful note,
When safe occasion offers, and with dance
And music of the bladder and the bag,
Beguile their woes and make the woods resound.
Such health and gaiety of heart enjoy
The houseless rovers of the sylvan world!
And breathing wholesome air and wandering much,
Need other physic none to heal the effects
Of loathsome diet, penury and cold.

THE STRICKEN DEER.

(From *The Task*, Book III.)

I was a stricken deer that left the herd
Long since; with many an arrow deep infixed
My panting side was charged, when I withdrew
To seek a tranquil death in distant shades.
There was I found by One who had Himself
Been hurt by the archers. In His side He bore,
And in His hands and feet, the cruel scars.
With gentle force soliciting the darts,
He drew them forth, and healed and bade me live.
Since then, with few associates, in remote
And silent woods I wander, far from those
My former partners of the peopled scene;
With few associates and not wishing more.
Here much I ruminate, as much I may,
With other views of men and manners now
Than once, and others of a life to come.
I see that all are wanderers, gone astray
Each in his own delusions; they are lost
In chase of fancied happiness, still wooed
And never won. Dream after dream ensues,
And still they dream that they shall still succeed,
And still are disappointed. Rings the world
With the vain stir. I sum up half mankind,
And add two-thirds of the remaining half,
And find the total of their hopes and fears
Dreams,—empty dreams.

ON THE LOSS OF THE ROYAL GEORGE.

Toll for the brave!—
  The brave that are no more!
All sunk beneath the wave,
  Fast by their native shore!
Eight hundred of the brave,
  Whose courage well was tried,

Had made the vessel heel,
And laid her on her side.
A land breeze shook the shrouds,
And she was overset;
Down went the Royal George,
With all her crew complete.

Toll for the brave!
Brave Kempenfelt is gone;
His last sea fight is fought,—
His work of glory done.
It was not in the battle;
No tempest gave the shock;
She sprang no fatal leak;
She ran upon no rock;
His sword was in its sheath;
His fingers held the pen,
When Kempenfelt went down
With twice four hundred men.

Weigh the vessel up,
Once dreaded by our foes;
And mingled with our cup
The tears that England owes.
Her timbers yet are sound,
And she may float again,
Full charged with England's thunder,
And plough the distant main.
But Kempenfelt is gone,
His victories are o'er;
And he and his eight hundred
Shall plough the wave no more.

Crabbe.—Lord Byron awards to a poet whose manner was entirely different from his own the high praise of being "Nature's sternest painter, but her best." This was the Rev. George Crabbe (1754-1832). His sombre, realistic tales, all written in the standard rhyming couplet, are now neglected, yet there must be merit in them to win Byron's commendation. He was born at Aldborough, a fishing village, which he afterward described in his poem *The Village.* He was apprenticed to a surgeon, and with great difficulty obtained enough knowledge of medicine to attempt its practice. But he failed to get a living and went to London with some verses for sale. After a vain struggle he was fortunate in securing the notice of Burke, who had his poem *The Library* printed in 1781. Burke also advised him to enter the Church, and when that was done procured him the position of chaplain to the Duke of Rutland. *The Village,* which is really a group of stories, was published in 1783, and in the same year the poet married a lady to whom he had been engaged for eight years. He obtained some small livings from Lord Thurlow, and at various intervals published similar collections of tales—*The Newspaper, The Parish Register, The Borough,* and lastly *The Tales of the Hall* in 1819. His fame rose steadily, and he was paid highly for his later poems. He was an acute observer of human nature and of plants. His firm resolve was to tell the truth and describe life exactly as he saw it. He rejected romance and painted with too much detail. Hence the mournful monotony of his works.

Scotch Poetry.—From the time of the union of Scotland with England, Scotchmen who felt inclination to literature generally went to London to try their fortune. Sometimes they succeeded, as did Thomson, more frequently, perhaps, they failed. Yet a few remained steadfast in their native land and cultivated their native dialect. The most noted of these in the first half of the eighteenth century was Allan Ramsay (1685-1758), son of a lead-miner, and for a time a barber. But his interest in the old songs and ballads of Scotland made him a bookseller and publisher. He gathered and published a collection of poems of the sixteenth century under the name *The Evergreen* (1724), and a more modern *Tea-Table Miscellany.* In the next year appeared his own pastoral, *The Gentle Shepherd.* It is a charming play in five acts, abounding in rustic humor and sentiment and interspersed with delightful songs. The Scotch peasantry welcomed it as a true dramatic expression of their national character. It may be noted that the word *gentle* in its title means "well-born," and that the shepherd Patie, who is the hero, is really the son of Sir William Worthy, while his Peggy likewise turns out to have been born a lady. The thoroughly democratic spirit of Burns had not yet pervaded literature. Ramsay, while singing in homely strains, took care not to offend the class-prejudices of his wealthy patrons. He watched the poetic market of London, and freely expressed in verse his feelings about the great authors and their works. Thus, after Addison's death, he published an elegiac pastoral, *Sandie and Ritchie.*

Robert Burns.—From Allan Ramsay's songs and poems the greater national poet of Scotland drew his first inspiration. Robert Burns (1759-1796) was the son of a devout, hard-headed farmer, near Ayr, and was trained to follow in his father's footsteps. But the farm did not prosper, while the poet's genius was developing fast. Deeply stirred by some parochial controversies he wrote his satires *The Holy Fair,* the *Twa Herds,* and the profane *Holy Willie's Prayer,* in which he exposed hypocrisy and self-righteousness. Yet at the same period, in a better spirit, he composed *The Cotter's Saturday Night,* a pleasing picture of a truly religious household. The cotter was his own father. The Spenserian stanza seems especially appropriate to the serious subject. It moves the mind like a solemn strain of music. While driving the plow Burns sang to himself brief lyrics on casual sights and incidents, as *The Mountain Daisy* and *The Mouse*, whose nest the plowshare had destroyed. His heart was in his verse when he wrote:

"But, Mousie, thou art no thy lane
In proving foresight may be vain;
The best laid schemes o' mice and men
Gang aft agley,
And leave us nought but grief and pain
For promised joy.

"Still thou art blest, compared wi' me!
The present only toucheth thee.
But och! I backward cast my e'e
On prospects drear,
And forward tho' I cannot see,
I guess and fear."

Burns' farming had failed, and he thought of sailing to Jamaica, if he could only raise the money to pay his passage. His brother suggested that he publish his poems, and he did so, adding *The Twa Dogs*. The little shabby book, printed at Kilmarnock, in 1786, on gray paper, with pasteboard cover, is now worth its weight in gold. The publication brought the poet a little money, and it brought him something more, a letter from Dr. Thomas Blacklock, a blind poet with influential friends, inviting him to Edinburgh. Burns went, and found friends at the University. A second edition of his poems brought more money and enabled him to take another farm. Burns, now in high spirits, wrote many love songs. In August, 1787, he was married to Jean Armour, whose father had previously refused his consent. To increase his income he got a place in the excise, and, three years later, being promoted, took his family to Dumfries. In the meantime he had written his *Tam O'Shanter*, humorously describing the drunken man's stormy midnight encounter with a wild dance of warlocks and witches. Burns himself was too much inclined to drinking, and in the exciting times of the beginning of the French Revolution his temptations were increased. His friendship for the French, too boldly expressed, brought reproofs from his superiors. In his struggle with poverty his health failed. He died in July, 1796.

Burns was always poor, and he sang the life and feelings of the poor. Yet he was none the less the poet of all mankind. To him rank does not make a man better, poverty does not make him worse. "The rank is but the guinea's stamp, a man's a man for a' that." He sang with a fellow-sinner's sympathy the sins and follies of the ne'er-do-weels as well as the sober righteousness of the pious. *The Jolly Beggars* is full of boisterous fun, while it depicts clearly low life and character.

Burns' poetry, even while it expresses a wider sympathy with mankind, retains the intense national spirit of older Scotch writers. He shows also the characteristic Scotch love of nature, and uses it as a background for human love. The moral of his short, unhappy life is too obvious—the deplorable weakness of the will in spite of the highest power of moving the emotions by song. The genius of Burns gave a strong impulse to the movement which was to change radically the nature and scope of literature in the next century.

THE COTTER'S FAMILY WORSHIP.

(From *The Cotter's Saturday Night.*)

The cheerfu' supper done, wi' serious face,
They, round the ingle, form a circle wide;
The sire turns o'er, wi' patriarchal grace,
The big ha' Bible, ance his father's pride;
His bonnet rev'rently is laid aside,
His lyart haffets wearing thin and bare;
Those strains that once did sweet in Zion glide,
He wales a portion with judicious care;
And, "Let us worship God," he says with solemn air.

They chant their artless notes in simple guise;
They tune their hearts, by far the noblest aim:
Perhaps "Dundee's" wild-warbling measures rise,
Or plaintive "Martyrs," worthy of the name;
Or noble "Elgin" beets the heavenward flame,
The sweetest far of Scotia's holy lays:
Compared with these Italian trills are tame;
The tickled ear no heartfelt raptures raise;
Nae unison hae they with our Creator's praise.

The priest-like father reads the sacred page,
How Abram was the friend of God on high;
Or, Moses bade eternal warfare wage
With Amalek's ungracious progeny:
Or how the royal bard did groaning lie
Beneath the stroke of Heaven's avenging ire;
Or Job's pathetic plaint, and wailing cry;
Or rapt Isaiah's wild seraphic fire;
Or other holy seers that tune the sacred lyre.

Perhaps the Christian volume is the theme,
How guiltless blood for guilty man was shed;
How He who bore in heaven the second name,
Had not on earth whereon to lay his head:
How his first followers and servants sped;
The precepts sage they wrote to many a land:
How he, who lone in Patmos banishéd,
Saw in the sun a mighty angel stand,
And heard great Bab'lon's doom pronounced by Heaven's command.

Then kneeling down, to Heaven's Eternal King,
The saint, the father, and the husband prays:
Hope "springs exulting on triumphant wing."
That thus they all shall meet in future days:
There ever bask in uncreated rays,
No more to sigh or shed the bitter tear,
Together hymning their Creator's praise,
In such society, yet still more dear;
While circling time moves round in an eternal sphere.

Compared with this, how poor religion's pride,
In all the pomp of method and of art,
When men display to congregations wide
Devotion's every grace, except the heart!
The Power incensed, the pageant will desert,
The pompous strain, the sacerdotal stole:
But, haply, in some cottage far apart,
May hear, well pleased, the language of the soul;
And in the book of life the inmates poor enrol.

Then homeward all take off their several way;
The youngling cottagers retire to rest;
The parent-pair their secret homage pay,
And proffer up to Heaven the warm request
That He, who stills the raven's clamorous nest,
And decks the lily fair in flowery pride,
Would, in the way His wisdom sees the best,
For them and for their little ones provide;
But, chiefly, in their hearts with grace divine preside.

From scenes like these old Scotia's grandeur springs,
That makes her loved at home, revered abroad:
Princes and lords are but the breath of kings,
"An honest man's the noblest work of God;"
And certes, in fair virtue's heavenly road,
The cottage leaves the palace far behind.
What is a lordling's pomp?—a cumbrous load,
Disguising oft the wretch of human kind,
Studied in arts of hell, in wickedness refined!

HIGHLAND MARY.

Ye banks, and braes, and streams around
The castle o' Montgomery,
Green be your woods, and fair your flowers,
Your waters never drumlie!
There simmer first unfaulds her robes,
And there the langest tarry;
For there I took the last fareweel
O' my sweet Highland Mary.

How sweetly bloom'd the gay green birk!
How rich the hawthorn's blossom!
As underneath their fragrant shade,
I clasped her to my bosom!
The golden hours on angel wings,
Flew o'er me and my dearie;
For dear to me as light and life,
Was my sweet Highland Mary!

Wi' mony a vow, and lock'd embrace,
Our parting was fu' tender;
And, pledging aft to meet again,
We tore ourselves asunder;
But, oh! fell Death's untimely frost,
That nipt my flower sae early!—
Now green's the sod, and cauld 's the clay,
That wraps my Highland Mary!

Oh, pale, pale now, those rosy lips,
I aft hae kis'd sae fondly!
And closed for aye the sparkling glance
That dwelt on me sae kindly!
And mouldering now in silent dust
That heart that lo'ed me dearly—
But still within my bosom's core
Shall live my Highland Mary!

CHAPTER VIII.

First Half of the Nineteenth Century.

A. D. 1800—1850.

Romanticism.—The eighteenth century has been pronounced by Masson a season "of comparative diminution of the general vital energy of our species." In contrast with this the nineteenth century showed from the start a vigorous revival of all the forces which actuate man and society. Even before the close of the preceding period there was a restiveness under the social despotism then prevailing. In literature some writers rejected the rules which had been imposed on poetic art by the precepts and practice of Pope. That poet, indeed, was but applying or adapting to English verse the rules which Boileau had prescribed for French, and which he supposed to be derived from the principles of the infallible Aristotle. But the strict construction of these rules made poetry altogether artificial. It excluded the natural expression of emotion, and confined its exercise to highly civilized society. It ignored the primal instincts of human nature. But nature cannot be permanently excluded from human thought nor from poetry, its highest expression. There came inevitably a reaction, which may be traced in part to the sentimental Rousseau, who boldly urged a return to an idealized savagery, and in part to German writers, who reveled in the freedom of utterance attending the revived use of their native tongue in literature.

This new literary movement, in which French, German and English writers were all involved, is known as Romanticism. It represented the same principles which in the political sphere produced the French Revolution. It was the triumph of the individual man over social systems and conventional rules. Young men of that time rejoiced in believing that the world was being made anew. Wordsworth who shared this feeling, wrote long afterward,

> "Bliss was it in that dawn to be alive,
> But to be young was very heaven."

Wordsworth, and some of his coevals, indeed became ultimately conservative in thought, but his genius was permanently benefited by his early radicalism. Others adhered steadfastly to the new faith in man and in human equality. In the republic of letters the result was freedom from constraint, stimulus of natural powers, unexpected development of new forms and subjects of literature. In France the Romantic movement, after winning memorable victories on the stage and elsewhere, gradually subsided, and classicism, which it vehemently opposed, resumed its sway. But in England the movement, inaugurated by Scott and accelerated by Byron, was progressive, though not uniformly. New forms appeared as time passed on and new writers arose. The mighty genius of Sir Walter Scott gave impulse to both prose and poetry, which lasted throughout the century. The meteoric brilliancy of Byron has lost some of its brightness before the steady effulgence of Wordsworth, Tennyson and Browning. Prose fiction, which Scott raised to the highest distinction, has steadily enlarged its domain and sought to treat all subjects relating to human life. To its victorious progress some of the greatest writers of the century contributed. In historical writing this period is hardly inferior to its predecessor. The long and generally peaceful reign of Queen Victoria is recognized as worthy of being classed with that of Elizabeth in the glory of its literature.

Sir Walter Scott.—The nineteenth century started splendidly with the vigorous and versatile genius of Sir Walter Scott (1771-1832). Born in Edinburgh, son of a lawyer, he spent his childhood in the romantic Scottish Border, and was imbued with its traditions of warfare and superstition. After passing through the University of Edinburgh he learned German, then a rare accomplishment. Filled with enthusiasm for its fresh romantic literature, he translated ballads from Burger and Goethe, and made a spirited version of *Goetz von Berlichingen.* In spite of lameness Scott was active on foot and horseback, and when, in 1799, he was made sheriff of Selkirkshire he utilized his gallop around the country to search out ballads and legends from old inhabitants. *The Minstrelsy of the Scottish Border* (1802), thus obtained, was a fair rival of Percy's *Reliques.* The Countess of Dalkeith was incited by it to request Scott to versify the story of the goblin page connected with her family traditions. Hence came *The Lay of the Last Minstrel* (1805), which was received with universal acclamation. No English poem had ever sold so widely before, and Scott devoted himself to authorship, while still remaining sheriff. Having ample means, he was induced to advance capital to James Ballantyne, the printer of his books. For a while the business seemed profitable, but being unduly enlarged ruined both partners.

The metre of the *Lay* was octosyllabic verse, derived originally from the Norman trouvères, and never before employed in English for serious poems. Its freedom from strict rules enabled the author to vary it as occasion required. Thus in passages expressing strong feeling or violent movement an occasional short verse was employed, while the longer lines rhyme sometimes in threes or fours. Scott's flowing versification echoes well the changing sentiment of the tale. The story of sorcery and chivalric adventure is admirably framed with the description of the aged minstrel, his diffidence in the presence of the great lady, his gradual recall of youthful inspiration, and his later outbursts of poetic exaltation.

After the unprecedented success of the *Lay,* Scott produced *Marmion* (1808), relating the visit of a valiant but unscrupulous English knight to Scotland, and concluding with the fatal field of Flodden in 1513. Very impressive is the immuring of Constance before a grim tribunal in the vaults of Lindisfarn Abbey. The battle is described with true Homeric directness, and the death of conscience-haunted Marmion is an appropriate conclusion. *The Lady of the Lake* (1810) is generally regarded as Scott's masterpiece. Here the civilized Lowlanders and the wild Highland clan, led by Roderick Dhu, meet in dire conflict. The reader is thrilled with the carrying of the Fiery cross to summon the clansmen to war, the battle of Beal' an Duine, and the death of Roderick.

The later metrical tales are of less importance. Scott, with his noble generosity to the merits of other writers, acknowledged that the more dazzling and forcible genius of Byron had surpassed his own, and he quietly withdrew from the poetic field. Great as had been his early success, he was to win greater triumphs in the new realm of prose fiction. Strange to say he had begun his first novel even before he wrote *Marmion,* but he laid the manuscript aside. Eight years later he took the story up again and finished it. It was sent forth anonymously under the title, *Waverley; or 'Tis Sixty Years Since.* Its purpose was to recall the stirring events of 1745, when the defeat of Culloden forever crushed the hopes of the Stuart Pretenders. The story was eagerly welcomed by the Scotch, who cherished traditions of the time. The author, though full of enthusiasm for his native, land and its people, had yet sufficient culture to treat his countrymen with the necessary aloofness for true perspective. One of his highest merits is that his works are free from the grossness and indecency which had prevailed in previous novel-writing. His dignified self-respect commended his work to an ever-widening circle of readers. *Guy Mannering,* his next story, shows a young Englishman venturing into Scotland and becoming involved in the fate of its people. Among its striking characters are Meg Merrilies, the Gypsy seeress, and Dominie Sampson, overflowing with learning and kindness. In a third vigorous sketch of Scotch life and manners, called *The Antiquary,* Scott made friendly sport of the foibles of his friend, George Constable, and, indeed, of his own. Even while issuing this series of anonymous fiction, Scott, to keep his printer partner busy, prepared under his own name treatises on chivalry, romance and the drama, edited the works of Dryden and Swift, issued new poems and wrote much for an *Annual Register.* Believing himself possessed of princely fortune, he had bought land at Abbotsford in 1812, and entered upon vast schemes for building a mediæval castle.

In *The Black Dwarf* and *Old Mortality* (1816) Scott entered on a new field of Scotch life, the struggles of the persecuted remnant, who maintained the binding obligation of the "Solemn League and Covenant," which made the government Presbyterian. When he was accused of treating the Covenanters unfairly he reviewed his own novels in the *Quarterly,* stating the principles and aims of historical romance. High praise for truth of character was rendered to the works of the unknown author. Rev. Dr. Thomas McCrie issued an able reply in vindication of the Covenanters. *Rob Roy* (1817) is a spirited presentation of Highland life and manners. But *The Heart of Midlothian,* the pathetic tale of Jeanie and Effie Deans, is perhaps the best of his novels in delineation of passion. *The Bride of Lammermoor* is a domestic tragedy of similar excellence. *The Legend of Montrose* is enlivened by the character of Major Dugald Dalgetty, pedantic soldier of fortune.

In 1819 the "Great Unknown," as the author was called, turned for the first time to England for the main scene of his story. *Ivanhoe* described that country in the time of lingering Norman and Saxon strife in the reign of Richard Coeur de Lion. The portrait of the Jewess Rebecca, one of his finest female characters, was suggested by Washington Irving's description of a lady of Philadelphia. *Ivanhoe* is free from the embarassment of the Scotch dialect, and rich in pictures of feudal chivalry. On this account it has always been the most popular of Scott's works. Another favorite, *Kenilworth,* relates Queen Elizabeth's visit to the Earl of Leicester's castle in Warwickshire, and her dramatic interview with the beautiful and unfortunate Amy Robsart. In *The Fortunes of Nigel* there is a vivid picture of London life, when the Scotch king had come to the English throne as James I.

Scott was in the zenith of his power when, in 1820, King George IV, on his visit to Edinburgh, conferred the honor of baronetcy on the foremost Scotch writer, who had personally arranged the King's welcome. He was widely known as the author of the Waverley Novels, though he had not yet publicly admitted the fact. In his next story, *Quentin Durward,* he crossed the Channel to portray the strife between the crafty, superstitious Louis XI of France and Charles the Bold of Burgundy. In other stories of less merit he returned to his native heath and presented both historic and domestic scenes. In the *Tales of the Crusaders* (1825) Richard Coeur de Lion and the Sultan Saladin are prominent. The grand array of historical personages presented in this long series of novels has never been surpassed in truthful delineation.

Scott had for some years believed himself entirely freed from pecuniary embarrassments by the arrangements made by his partners in 1818. But the financial crash of 1825 carried down the London and Edinburgh houses with which the Ballantynes were involved. What was Scott's astonishment to find himself, at the age of fifty-four, legally liable for not less than £130,000! He might have taken advantage of the bankrupt law, but his pride or high sense of honor would not permit. Refusing all assistance, with dauntless courage he determined to pay his debts or die in the effort. He suffered other misfortunes, among which was the death of his wife. Leaving the grandeur of Abbotsford, he took modest lodgings in Edinburgh. Yet there were alleviations to his distress. An opportunity was afforded at a public testimonial in his behalf for him to acknowledge the paternity of his popular works. The secret had been well guarded, but had long been suspected. In three months Scott wrote *Woodstock,* a tale of Charles II's wanderings and restoration to the throne. Within two years, as the proceeds of some novels, including *The Fair Maid of Perth,* an elaborate but strongly prejudiced *Life of Napoleon Bonaparte,* and *Tales of a Grandfather,* which relate the history of Scotland, the prolific author had accumulated £40,000 for his creditors. But even his strong constitution could not stand such a steady drain on its vitality. Illness began in 1829, and partial paralysis followed. Yet in spite of friends and physicians Scott would not take rest. His last novels, *Count Robert of Paris* and *Castle Dangerous,* show signs of failing powers. At last he was led to believe that his debts were paid, and then consented to take a sea voyage, recommended by his physicians. The government offered the use of a vessel, in which he sailed for Naples and cruised about the Mediterranean for some months. When he felt that his end was near he insisted on being taken back to Abbotsford. There the greatest of Scotchmen died, September 21st, 1832.

Monuments have been erected to his memory in Edinburgh and other cities, but his true monument is Scotland itself, nearly every province and town of which has been made familiar by his magic pen. "The Wizard of the North" conjured up the men and manners of the past, and bestowed upon their land an imperishable fame. His works abound in wonderful variety of character and incident; while he excelled in delineating the Scotch of both high and low degree, his historical and antiquarian researches, vivified by his strong imagination, enabled him to present life-like portraits of other nationalities and remote periods. He was not only the father of the true historical novel, but his example was the teacher of historians, leading them beyond chronological details and philosophical abstractions to portrayal of human life. His genius was able not merely to entertain millions of readers, but to inaugurate a revival of interest in the history, art and life of the Middle Ages, and thus lead to a transformation of his own time. To Scott may well be applied the lines which he wrote of King René:

"A mirthful man he was; the snows of age
Fell, but they did not chill him. Gaiety,
Even in life's closing, touched his teeming brain
With such wild visions as the setting sun
Raises in front of some hoar glacier,
Painting the bleak ice with a thousand hues."

THE HYMN OF INTERCESSION.

(From *The Lay of the Last Minstrel.*)

Slow up the dim aisle afar,
With sable cowl and scapular,
And snow-white stoles, in order due,
The holy Fathers, two and two,
In long procession, came;
Taper and Host, and book they bare,
And holy banner, flourished fair
With the Redeemer's name.
Above the prostrate pilgrim band
The mitred Abbot stretched his hand,
And blessed them as they kneeled.
With holy cross he signed them all,
And prayed they might be sage in hall
And fortunate in field.
Then the mass was sung, and prayers were said,
And solemn requiem for the dead;
And bells tolled out their mighty peal
For the departed spirit's weal.
And ever in the office close
The hymn of intercession rose;
And far the echoing aisles prolong,
The awful burthen of the song:—
Dies Iræ, Dies illa,
Solvet sæclum in favilla.
While the pealing organ rung,
Thus the holy fathers sung:—

"That Day of Wrath, that dreadful day
When heaven and earth shall pass away,
What power shall be the sinner's stay?
How shall he meet that dreadful day?

When shriveling like a parchéd scroll,
The flaming heavens together roll;
And louder yet, and yet more dread,
Swells the high trump that wakes the dead;

Oh! on that day, that dreadful day,
When man to judgment wakes from clay,
Be thou the trembling sinner's stay,
Though heaven and earth shall pass away."

THE PARTING OF MARMION AND DOUGLAS

(From *Marmion.*)

Not far advanced was morning day,
When Marmion did his troop array
To Surrey's camp to ride;
He had safe conduct for his band
Beneath the royal seal and hand,
And Douglas gave a guide:
The ancient Earl, with stately grace,
Would Clara on her palfrey place,
And whispered, in an undertone,
"Let the hawk stoop, his prey is flown."
The train from out the castle drew,
But Marmion stopped to bid adieu.—
"Though something I might plain," he said,
"Of cold respect to stranger guest,
Sent hither by your king's behest,
While in Tantallon's towers I staid;
Part we in friendship from your land,
And, noble Earl, receive my hand."
But Douglas round him drew his cloak,
Folded his arms, and thus he spoke:
"My manors, halls, and bowers shall still
Be open at my Sovereign's will,
To each one whom he lists, howe'er
Unmeet to be the owner's peer.
My castles are my king's alone,
From turret to foundation stone—
The hand of Douglas is his own;
And never shall in friendly grasp
The hand of such as Marmion clasp."

Burned Marmion's swarthy cheek like fire
And shook his very frame for ire,
And—"This to me!" he said,—
"An' 'twere not for thy hoary beard,
Such hand as Marmion's had not spared
To cleave the Douglas' head!
And, first, I tell thee, haughty peer,
He who does England's message here,
Although the meanest in her state,
May well, proud Angus, be thy mate.
And, Douglas, more I tell thee here,
E'en in thy pitch of pride,
Here in thy hold, thy vassals near,
(Nay never look upon your lord,
And lay your hands upon your sword,)
I tell thee, thou'rt defied!
And if thou said'st I am not peer
To any lord of Scotland here,
Lowland or Highland, far or near,
Lord Angus, thou hast lied!"—
On the Earl's cheek the flush of rage
O'ercame the ashen hue of age:
Fierce he broke forth,—"And dar'st thou then
To beard the lion in his den,
The Douglas in his hall!
And hop'st thou hence unscathed to go?
No, by St. Bride of Bothwell, no!
Up drawbridge, grooms!—what, warder, ho!
Let the portcullis fall."—
Lord Marmion turned—well was his need,
And dashed the rowels in his steed,
Like arrow through the archway sprung,
The ponderous gate behind him rung:
To pass there was such scanty room,
The bars, descending, grazed his plume.

The steed along the drawbridge flies,
Just as it trembled on the rise;
Nor lighter does the swallow skim
Along the smooth lake's level brim:
And when Lord Marmion reached his band
He halts, and turns with clenchéd hand,
And shouts of loud defiance pours,
And shook his gauntlet at the towers,
"Horse! horse!" the Douglas cried, "and chase!"
But soon he reined his fury's pace.
"A royal messenger he came,
Though most unworthy of the name.
St. Mary mend my fiery mood!
Old age ne'er cools the Douglas' blood,
I thought to slay him where he stood.—
'Tis pity of him, too," he cried:
"Bold can he speak, and fairly ride,
I warrant him a warrior tried."—
With this his mandate he recalls,
And slowly seeks his castle halls.

Lord Byron.—Though not the originator of Romanticism, being, in fact, originally a conservative, Lord Byron became the most active factor in its progress throughout Europe, from France to distant Russia. In all his verse-stories he was his own passionate hero. When cut off at the early age of thirty-six, he had already bestowed on the world an astonishing contribution to its literature.

George Gordon Byron (1788-1824), though born in London, spent his childhood in bleak Aberdeen, where his mother, who had been deserted by her dissipated husband, went to live on a slender income. An accident at birth had injured one of his feet, which was ever a source of mortification. At the age of eleven he succeeded to the title and estates of his granduncle, and removed to Newstead Abbey. For education he went to Harrow School and Trinity College, Cambridge, where he scribbled verses. His first publication, *Hours of Idleness* (1807), was severely criticized in the *Edinburgh Review*. The young poet was roused to fury and vehemently assailed the whole literary craft in his *English Bards and Scotch Reviewers*. When of age, he took his seat in the House of Lords, but had few acquaintances, and soon set out on a tour through Southern Europe. The literary result of two years' travel was *Childe Harold's Pilgrimage* (1811), a poem in the Spenserian stanza. War had for some years kept the English people from the Continent; now they were delighted to receive brilliant pictures of scenery and countries long lost to view. The traveler was an outcast from his native land, consumed with melancholy, seeking distraction from himself. So powerful was the immediate impression of the work that Byron exclaimed: "I awoke one morning and found myself famous." The doors of the rich and noble were opened to the author. His pale, melancholy features captivated women; his sweet voice and graceful form attracted every eye. He was flattered and idolized, but he did not yield to utter idleness. Borrowing Scott's metre, he poured forth poetical tales of the East; first, *The Giaour* (1811), whose title means unbeliever, and is applied by Mohammédans to Christians; then *The Bride of Abydos* (1813), *The Corsair* (1814), *Lara* (1814), and *The Siege of Corinth* (1816). Each story was different, but one hero appeared in them all,

"The man of loneliness and mystery,
Scarce seen to smile, and seldom heard to sigh."

In January, 1815, Lord Byron married Miss Anne Isabella Milbanke, a lady of wealth and position; but a year later, after the birth of a daughter, she separated from him. She was of severe morals and unsympathetic; he was licentious and of violent temper; she thought him actually insane. Public opinion in England condemned the husband and he went abroad full of bitterness. At Geneva he wrote another canto of *Childe Harold*, and *The Prisoner of Chillon*. In 1817 he formed a liaison with the Countess Guiccioli, which was maintained through the rest of his life at Venice and other cities. But his literary work was continued without intermission. It included *Don Juan, Mazeppa,* the dramas *Marino Faliero,* and *The Two Foscari,* and less important pieces.

In 1823 Byron resolved to take an active part in the Greek struggle for independence. He sailed from Genoa with arms, but found the insurgents insubordinate and not prepared for action. Seized with fever at Missolonghi, he died April 19, 1824.

Bryon's mind teemed with the stormy thoughts of his period, and thus he became the poet of revolution, able to rouse mankind against restraint. His descriptions are grand and varied, and he often concentrated scenes in a line. There is manifest improvement in the later cantos of *Childe Harold* beyond those which gave him his first fame, but it is thoroughly serious from beginning to end. Byron had no real dramatic genius, yet he wrote several dramas, in which the principal personages declaim in long soliloquies on their woes and wrongs and despair. *Don Juan* is Byron's longest work and the fullest exhibit of his character and poetical power. The idea is old, but the rendering is new, giving a splendid epic with an inglorious hero. It combines tragic and comic scenes and lines in a fantastic manner. Its sublime and exquisite descriptions should elevate the mind, but vile and ignoble associations are freely admitted. The metre and method of treatment are borrowed from the Italian burlesque poets, but in manner the poem is highly original. To the series of pictures of human life and society the author adds piquant satire or jesting comment.

GREECE IN HER DECAY.

(From *The Giaour.*)

He who hath bent him o'er the dead,
Ere the first day of death is fled—
The first dark day of nothingness,
The last of danger and distress,
(Before Decay's effacing fingers
Have swept the lines where beauty lingers),
And marked the mild angelic air,
The rapture of repose that's there;
The fixed yet tender traits that streak
The languor of that placid cheek,
And—but for that sad shrouded eye,
That fires not, wins not, weeps not, now,
And but for that chill changeless brow,
Where cold Obstruction's apathy
Appals the gazing mourner's heart
As if to him it could impart
The doom he dreads, yet dwells upon;
Yes, but for these, and these alone,
Some moments—aye, one treacherous hour—
He still might doubt the tyrant's power:—
So fair, so calm, so softly sealed,
The first, last look by death revealed.
Such is the aspect of this shore:
'Tis Greece—but living Greece no more!
So coldly sweet, so deadly fair,
We start, for soul is wanting there.
Hers is the loveliness in death,
That parts not quite with parting breath;
But beauty with that fearful bloom,
That hue which haunts it to the tomb,
Expression's last receding ray,
A gilded halo hovering round decay,
The farewell beam of feeling past away!
Spark of that flame, perchance of heavenly birth,
Which gleams, but warms no more its cherished earth.
Clime of the unforgotten brave!
Whose land, from plain to mountain cave,
Was Freedom's shrine or Glory's grave!
Shrine of the mighty! can it be
That this is all remains of thee?

WATERLOO.

(From *Childe Harold's Pilgrimage,* Canto III.)

Stop! for thy tread is on an Empire's dust!
An earthquake's spoil is sepulchred below!
Is the spot marked by no colossal bust?
Nor column trophied for triumphal show?
None; but the moral's truth tells simpler so,
As the ground was before, thus let it be;—
How that red rain hath made the harvest grow!
And is this all the world has gained by thee,
Thou first and last of fields! King-making victory?

There was a sound of revelry by night,
And Belgium's capital had gather'd then
Her beauty and her chivalry, and bright
The lamps shone o'er fair women and brave men;
A thousand hearts beat happily; and when
Music arose with its voluptuous swell,
Soft eyes look'd love to eyes which spoke again;
And all went merry as a marriage-bell:
But hush! hark! a deep sound strikes like a rising knell!

Did ye not hearit?—No; 'twas but the wind,
Or the car rattling o'er the stony street;
On with the dance! let joy be unconfined;
No sleep till morn, when Youth and Pleasure meet
To chase the glowing hours with flying feet—
But hark!—that heavy sound breaks in once more,
As if the clouds its echo would repeat;
And nearer, clearer, deadlier than before!
Arm! Arm! it is—it is the cannon's opening roar!

Within a window'd niche of that high hall
Sat Brunswick's fated chieftain; he did hear
That sound the first amidst the festival,
And caught its tone with Death's prophetic ear;
And when they smiled because he deemed it near,
His heart more truly knew that peal too well
Which stretch'd his father on a bloody bier,
And roused the vengeance blood alone could quell:
He rush'd into the field, and foremost fighting, fell.

Ah! then and there was hurrying to and fro,
And gathering tears, and tremblings of distress,

And cheeks all pale, which but an hour ago
  Blush'd at the praise of their own loveliness;
And there were sudden partings, such as press
  The life from out young hearts, and choking sighs
Which ne'er might be repeated; who could guess
  If ever more should meet those mutual eyes,
Since upon night so sweet such awful morn could
    rise!

And there was mounting in hot haste: the steed,
  The mustering squadron, and the clattering car,
Went pouring forward with impetuous speed,
  And swiftly forming in the ranks of war;
And the deep thunder, peal on peal afar;
  And near, the beat of the alarming drum
Roused up the soldier ere the morning star;
  While thronged the the citizens with terror dumb,
Or whispering with white lips—"The foe! They
    come! they come!" . . . .

And Ardennes waves above them her green leaves,
  Dewy with Nature's tear-drops, as they pass,
Grieving—if aught inanimate e'er grieves—
  Over the unreturning brave; alas!
Ere evening to be trodden like the grass
  Which now beneath them, but above shall grow
In its next verdure, when this fiery mass
  Of living valor, rolling on the foe,
And burning with high hope, shall moulder cold
    and low.

Last noon beheld them full of lusty life,
  Last eve in Beauty's circle proudly gay,
The midnight brought the signal-sound of strife,
  The morn the marshalling in arms; the day
Battle's magnificently stern array!
  The thunder-clouds close o'er it, which when rent
The earth is covered thick with other clay
  Which her own clay shall cover, heaped and pent,
Rider and horse—friend, foe—in one red burial blent!

THE SHIPWRECK.

(From *Don Juan*, Canto II.)

'Twas twilight, and the sunless day went down
  Over the waste of waters: like a veil,
Which, if withdrawn, would but disclose the frown
  Of one whose hate is masked but to assail.
Thus to their hopeless eyes the night was shown,
  And grimly darkled o'er the faces pale,
And the dim desolate deep. Twelve days had Fear
Been their familiar: and now Death was near. . . .

At half-past eight o'clock, booms, hencoops, spars,
  And all things, for a chance, had been cast loose,
That still could keep afloat the struggling tars—
  For yet they strove, although of no great use:
There was no light in heaven but a few stars.
  The boats put off, o'ercrowded with their crews.
She gave a heel, and then a lurch to port;
And, going down head foremost—sank, in short.

Then rose from sea to sky the wild farewell;
  Then shrieked the timid, and stood still the brave;
Then some leaped overboard with dreadful yell,
  As eager to anticipate their grave;
And the sea yawned around her, like a hell;
  And down she sucked with her the whirling wave,
Like one who grapples with his enemy,
And strives to strangle him before he die.

At first one universal shriek there rushed,
  Louder than the loud ocean, like a crash
Of echoing thunder; and then all was hushed,
  Save the wild wind, and the remorseless dash
Of billows. But at intervals there gushed,
  Accompanied with a convulsive splash,
A solitary shriek—the bubbling cry
Of some strong swimmer in his agony.

Thomas Moore.—Closely associated with Byron in his lifetime, and afterward his biographer, was Thomas Moore (1779-1852). His once popular *Irish Melodies* have not lost all their charm. Besides his Celtic faculty of writing verses for singing, he was a lively conversationalist, and thus became a favorite with the Whig aristocracy. Born in Dublin, he early showed literary talent, and graduated at Trinity College in 1800. Going to London he obtained permission to dedicate his translation of Anacreon to the Prince Regent, afterward George IV, and for a while was the pet of London society. In 1803 he was appointed to an official post in the Bermudas, but leaving it in charge of a deputy, he traveled in the United States. On his return to London he was welcomed by the world of fashion and satirized the Americans. His travels suggested other subjects for his lyrics. His *Irish Melodies,* adapted to ancient tunes, newly arranged, began to appear in 1807, and many additions were made in later years, making altogether about one hundred and twenty songs. These fascinating amatory and patriotic effusions rescued from vulgar associations the music of his native land, and are the best expression of his powers. Enterprising publishers offered the brilliant poet 3000 guineas for an Oriental tale to be written in a year. Though he had never visited the East, he endeavored to steep his mind in Persian lore and imagery, and poured it out in the gorgeous *Lalla Rookh.* It relates, in a framework of prose, the pilgrimage of the beautiful daughter of the Indian Emperor Aurungzebe, who, being betrothed to the Prince of Bucharia, set out from her royal home to meet him. The tedium of the caravan journey is beguiled by the charming recitations of a poet, with whom, ere she has reached her destination, she discovers she has fallen in love. But happily when she is presented at the Persian court she beholds on the throne the poet who had won her heart.

Moore's deputy in the Bermudas abused his trust, and the principal, being called on to make good his embezzlement, was plunged into pecuniary difficulties. He fled to the Continent, but kept up his literary labor. In *The Fudge Family in Paris* he satirized the boorishness of English travelers. The *Life, Letters and Journals of Lord Byron* (1830) was a tribute of friendship, candidly expressed. In spite of some triviality of character, Moore was loyal to his native land, to his religion, and to his political party. In old age he occupied a cottage on the estate of the Marquis of Lansdowne. His five children died before him; his mental powers failed, but his faithful wife survived him.

Burns and Moore were the lyrists of two kindred peoples. But the songs of the latter, though exquisitely sweet, have been polished for fine society and do not reach the heart so readily as the artless strains of the former. "The Muse of the Irish lawyer is crowned with a circlet of shining gems; the Muse of the Scottish peasant wears a garland of sweet field flowers."

Shelley.—History records several instances of aristocrats impelled by observation of the wrongs of civilized society to become revolutionists in thought or action. To this class belonged the refined, sensitive, scholarly atheist, Percy Bysshe Shelley (1792-1822). He was the eldest son of a wealthy baronet, was educated at Eton and Oxford, but was expelled from the University, in 1811, for an atheistic publication. The wild and fantastic poem *Queen Mab* (1813) expressed more boldly the same opinions. At the age of nineteen the impulsive Shelley, partly out of pity, married Harriet Westbrook, a girl of sixteen, daughter of an inn-keeper, and was renounced by his family, though his father granted him a moderate allowance. The youthful couple wandered on the Continent, but the marriage proved unhappy, and they separated after the birth of two children. Before his first wife died, in 1816, Shelley found more congenial companionship with Mary Godwin.

In 1818 he published *The Revolt of Islam,* a poem, which, under another title, had been prohibited by the authorities. The aim of this declamatory narrative was to show the triumph of his philanthropic theories over the tyranny and hypocrisy of established religious systems. When the courts deprived Shelley of the custody of his children he went to Italy, where he produced his best poetry. His *Prometheus Unbound* is an attempt to solve the great problem of human free will, on the lines suggested by the *Prometheus* of Aeschylus. Shelley was well versed in Greek, and an ardent Platonist. His *Prometheus* is the personification of resistance to universal tryanny and priestcraft. His drama of *The Cenci* is founded on a horrible story of revolting crime in the Italian Middle Ages. In the elegy, *Adonais* (1821), Shelley lamented in noble Spenserian verse the ultimely death of the poet Keats. His last poem, *Hellas,* expressed his hope of a grander and better golden age than that of ancient Greece. His death was singular and melancholy. While he was returning in a small yacht from Leghorn to Spezzia, the vessel was caught in a squall, and Shelley, with two companions, perished.

There seems to be an almost inexplicable contrast between the man Shelley and his early works. As a man, he was mild, benevolent, temperate, his person was extremely delicate and refined. His best poetry is full of tender, spiritual harmony; his diction, choice and transparent; his power of imagination inexhaustible, carrying the mind far beyond the original idea, and introducing a perpetual interchange betwen the type and the things typified. But in his early works he exaggerated the horrible and repulsive, and used a fierce declamatory tone, which repels instead of attracting or convincing. A later generation of readers has learned to reject these extravagant outbursts and to dwell upon his sweet, graceful and ethereal lyrics as the true expression of his genius.

Keats.—Another remarkable manifestation of the poetic spirit of this period was John Keats (1795-1821). Born in humble circumstances in London, he was, at fifteen, apprenticed to an apothecary. His sympathy with the great English poets and with the Greek mythology, though he knew nothing of that language, led to his composing a long narrative poem, *Endymion.* It was published in 1818, inscribed to the memory of Chatterton, whom the new poet somewhat resembled. The highly ambitious epic was assailed severely by the leading reviewers. The poor consumptive Keats was wounded in spirit, yet, conscious of poetic power, he persevered in his chosen line. In 1820 appeared *Lamia,* the pathetic *Isabella,* the beautiful *Eve of St. Agnes,* and the classical fragment, *Hyperion.* The improvement in style and treatment won for them a more favorable reception than his first attempts. Keats, in expression and native melody, was of kin to Shelley, but was content to live in the enjoyment of his poetic dreams without attempting to make an evil world better by savage denunciation. Gifted with fine fancy and a genuine predilection for Greek ideas, the slight errors due to his lack of careful culture are easily pardoned. Attacked with hemorrhage, he went to Italy, where he died in February, 1821, leaving as his epitaph, "Here lies one whose name was writ in water."

Wordsworth.—The greatest, though not the most popular, poet of this period was William Wordsworth (1770-1850). In the eighteenth century a new love of nature had sprung up, which is exemplified in the works of Thomson and Cowper, but it did not dare to antagonize the artificial style inculcated by the precept and example of Pope. Wordsworth deliberately attacked this artificial correctness and demanded the expression of primal truth in natural manner. In his early utterances he was carried too far by his theory, but he finally brought his poetic phrase into harmony with his elevated sentiment.

Wordsworth was born in Cumberland, where his ancestors had held land for centuries, and thus acquired his strong susceptibility for the beauty of nature. He was educated at Cambridge, and traveled in France in 1791. He hailed with ardent feeling the new era of humanity which he friends burned it on a funeral pyre in the ancient then believed was opened by the French Revolution. But lack of money compelled him to return, and for three years his prospects were uncertain. Then a legacy from a friend enabled him to pursue his natural bent. With his sister, Dorothy, he took a simple cottage and resolved to dedicate himself to poetry. He had already published two poems, when he came in contact with the persuasive and stimulating Coleridge. The two poets published the *Lyrical Ballads* (1798), which embodied their new notions. In the preface to the second edition (1800) Wordsworth declared that true poetry is "the spontaneous overflow of powerful feelings;" its language is therefore the simple, direct utterance of the heart; its proper subjects are not strong passions, revenge, ambition, unbridled love, but the tranquil virtues, the development of the affections, and the effort of the soul to unite itself with God. The themes which Wordsworth chose were pronounced by the *Edinburgh Review* to be trivial and vulgar. But the self-centered poet was not to be swerved by the judgments of critics; on he moved calmly, composing his meditative and reflective poems on simple incidents of life, yet rising at times to lofty and impassioned utterances on the Divinity which he beheld in nature. To him external nature was a conscious expression of the Supreme Being. His tendency to a mysterious, sublime pantheism was held in check only by his profound belief in the Christian revelation.

From 1813 Wordsworth lived at Rydal Mount, sustained in steadfast devotion to lofty purpose by the cheerful companionship of his sister, Dorothy, and his wife. His poems were received at first with ridicule and protest by nearly all the critics. Gradually the tide turned; Oxford bestowed on him the degree of D.C.L., in 1839, and Sir Robert Peel made him poet laureate in 1843. He held the honorable post for seven years and did not demean himself by trifling congratulatory verses as his predecessors had done. English public opinion had come to recognize him as a poet above Pope and Dryden, Thomson and Cowper, and almost on a level with Milton. The drawback to his fame is that he wrote too much, so that some parts are dull and unworthy. His theory of poetic diction sometimes spoiled his utterance owing to his lack of humor. In his later work he discarded the extreme simplicity and puerility which offended the early critics.

His great merit lies in his power of delineating nature and the poetic force which his tendency to pantheism adds to this gift. Many noble lines record his strong feeling at special times and places. Especially in his *Tintern Abbey* and *Ode on Intimations of Immortality from the Recollections of Childhood,* he rose to sublime heights, even above the limit reached in other valuable verses. His longest poem, *The Excursion,* is but a fragment of a projected epic, in which a Scotch pedlar, a clergyman, and a disappointed visionary discuss fundamental questions concerning God and man, the problems of human life and duties. *The Prelude,* which was intended as an introduction to this epic, was published after the author's death. Wordsworth took up the sonnet, which had been long neglected by English poets, and gave it new vogue. His *Westminster Bridge* and *The World is Too Much With Us* rank among the best sonnets in English literature.

ODE TO DUTY.

Stern Daughter of the Voice of God!
O Duty! if that name thou love
Who art a light to guide, a rod
To check the erring, and reprove;
Thou, who art victory and law
When empty terrors overawe;
From vain temptations dost set free;
And calm'st the weary strife of frail humanity!

There are who ask not if thine eye
Be on them; who, in love and truth,
Where no misgiving is, rely
Upon the genial sense of youth:
Glad Hearts! without reproach or blot;
Who do thy work, and know it not:
Long may the kindly impulse last!
But Thou, if they should totter, teach them to stand fast!

Serene will be our days and bright,
And happy will our nature be,

When love is an unerring light,
And joy its own security.
And they a blissful course may hold
Even now, who, not unwisely bold,
Live in the spirit of this creed;
Yet find that other strength, according to their need.

I, loving freedom, and untried,
No sport of every random gust,
Yet being to myself a guide,
Too blindly have reposed my trust:
And oft, when in my heart was heard
Thy timely mandate, I deferred
The task, in smoother walks to stray;
But thee I now would serve more strictly, if I may.

Through no disturbance of my soul,
Or strong compunction in me wrought,
I supplicate for thy control,
But in the quietness of thought:
Me this unchartered freedom tires;
I feel the weight of chance-desires;
My hopes no more must change their name,
I long for a repose that ever is the same.

Stern Lawgiver! yet thou dost wear
The Godhead's most benignant grace;
Nor know we anything so fair
As is the smile upon thy face:
Flowers laugh before thee on their beds;
And fragrance in thy footing treads;
Thou dost preserve the stars from wrong;
And the most ancient heavens, through Thee, are fresh and strong.

To humbler functions, awful Power!
I call thee: I myself commend
Unto thy guidance from this hour;
Oh, let my weakness have an end!
Give unto me, made lowly wise,
The spirit of self-sacrifice;
The confidence of reason give;
And in the light of truth thy Bondman let me live!

MILTON.

Milton! thou should'st be living at this hour:
England hath need of thee: she is a fen
Of stagnant waters: altar, sword, and pen,
Fireside, the heroic wealth of hall and bower,
Have forfeited their ancient English dower
Of inward happiness. We are selfish men.
Oh! raise us up, return to us again;
And give us manners, virtue, freedom, power.
Thy soul was like a star, and dwelt apart:
Thou had'st a voice whose sound was like the sea:
Pure as the naked heavens, majestic, free,
So didst thou travel on life's common way,
In cheerful godliness; and yet thy heart
The lowliest duties on herself did lay.

ON WESTMINSTER BRIDGE.

Earth has not anything to show more fair:
Dull would he be of soul who could pass by
A sight so touching in its majesty:
This city now doth like a garment wear
The beauty of the morning; silent, bare,
Ships, towers, domes, theatres, and temples lie
Open unto the fields, and to the sky;
All bright and glittering in the smokeless air.
Never did sun more beautifully steep
In his first splendor valley, rock, or hill;
Ne'er saw I, never felt, a calm so deep!
The river glideth at his own sweet will:
Dear God! the very houses seem asleep;
And all that mighty heart is lying still!

Coleridge.—Though intimately associated with Wordsworth in his youth, Samuel Taylor Coleridge (1772-1834) was yet of entirely different character, "a subtle-souled psychologist," as Shelley called him. He wrote abundant prose and verse of many kinds, but was influential rather as a suggester and inspirer than an actual performer. With all his ability his intellectual work was fragmentary and his career a melancholy failure.

At the famous Charterhouse or Blue-coat school, in London, he formed a lasting friendship with Charles Lamb. Afterward he went to Jesus College, Cambridge, but got into difficulties, enlisted as a dragoon, and was bought off by friends. When he left the University again he fell in with Southey, and the two became engaged to sisters at Bristol in 1794. Both were filled with revolutionary ideas and formed a vague scheme of renovating humanity by founding on the banks of the Susquehanna a community to be called Pantisocracy (equal government of all). But for want of money this scheme fell through. Coleridge married Sara Fricker in 1795, became a Unitarian preacher, published some poems, and started a weekly paper. At Stowey he became acquainted with Wordsworth, and contributed to the *Lyrical Ballads* "The Rime of the Ancient Mariner," and a few other poems.

After a year's visit to Germany Coleridge settled with Southey and Wordsworth in the Lake district. The three Radicals now became Conservatives. As poets they had mutual effect on each other's work. Coleridge's philosophic insight did much to elevate Wordsworth's later poems. Coleridge translated freely Schiller's trilogy of *Wallenstein,* enriching the drama. This was the period of his chief productiveness as a poet. He seemed afterward to have lost the creative power, and became critical or metaphysical. He went to Malta as secretary to the Governor. After his return he engaged in newspaper work and lecturing, and published two dramas and some poems. Fertile in schemes, literary and philosophical, he was incompetent to execute them in a reasonable degree. In trying to relieve neuralgic pain he became a victim of the opium habit, and was unable to keep house with his own family, but was sheltered by friends who had regard for his abilities. Dr. Gilman is especially remembered for this service, and at his house, in Highgate, Coleridge resided for eighteen years. There he discoursed eloquently to visitors, but wrote little for publication.

As a poet Coleridge is best remembered by a few exquisite pieces—"The Ancient Mariner," "Love, or Genevieve," and the fragments, "Christabel" and "Kubla Khan." They all exhibit wonderful command of metre, language and the power of exciting emotion. His other poems vary in excellence, sometimes sinking to worthlessness. His *Biographia Literaria* contains much excellent criticism. To the *Encyclopedia Metropolitana* this unmethodical man contributed an introduction on "Method" and laid down the plan of the work. His other prose writings were written piecemeal, but have been diligently collected by several editors. Among them occasional gems may be found, but their general value is diminished by their lack of connection or completion. Yet this rambling soliloquist had wide-reaching effect on the higher thought, philosophy and literature of England.

Southey.—Another youthful radical who became in mature life a staunch Tory was Robert Southey (1774-1843). His early publications were revolutionary in tone, but not wildly atheistic like Shelley's. But when he settled down to steady work for the *Quarterly Review* he was an unflinching supporter of Church and State. In 1813 he was made poet laureate, and held the position for thirty years.

Robert Southey was born at Bristol, and went to Balliol College, Oxford, but left without taking a degree. Infatuated with the wildest revolutionary doctrines, he published the drama of *Wat Tyler* (1794). His Utopian scheme, learnedly called Pantisocracy, perished still-born. In 1795 Southey married Edith Fricker, yet immediately went alone to Lisbon, where his uncle was a British chaplain. The visit led to his thorough study of Spanish and Portuguese history and literature, which proved of service in later years. In 1804 he settled at Greta Hall, near Keswick, in the Lake country, and thenceforward led a laborious literary life, assisted by the generosity of his friends, yet grinding away on topics of the time for daily bread. When Coleridge deserted his family, Southey took up the additional burden. His most ambitious undertaking was to illustrate the mythologies of the world in a series of poems. *Thalaba, the Destroyer,* is founded on Arabian traditions, and celebrates the victory of faith over the powers of evil. *The Curse of Kehama* was founded on the Hindoo mythology, whose extravagant fables and horrors overtaxed the powers of the poet and the patience of his readers. In his next epic, *Madoc,* Southey made use of Welsh traditions in regard to an early discovery of America. It was the least successful of his long poems. The most popular was *Roderick,* the tragic story of the last Gothic king of Spain. For the Christian king's sin his people were defeated by the Moors, but Roderick, escaping, though supposed to be killed, became a hermit. Called by a vision to redeem his people, he wandered through the country in the garb of a priest and rallied his friends to a new conflict with the Moors. In the battle he was recognized by his war-cry, but after the victory he disappeared.

All of these poems required an immense amount of reading in order to gather the material and proper surroundings. In fact, Southey's writing, both in prose and verse, was based upon the most painstaking investigation, and his wildest fancies wear a matter-of-fact shape. Though he won high praise, he never was popular; for his toilsome works he received far less compensation than Moore and men of less note for airy fancies. When his poetry became unprofitable he confined himself to prose, though even in this he did not find time to accomplish the great works which he had planned. As a poet Southey is remembered by a few short pieces; as a prose-writer, by his biographies of Nelson and Wesley, and by the whimsical rambling work, *The Doctor,* which was an improvement in decency, though not in lively interest, on its model, Sterne's *Tristram Shandy.*

Rogers and Campbell.—Besides the men of genius already described, there were several contemporaries of fair repute. The eldest of these, who lived to the age of ninety-two, was Samuel Rogers (1763-1855), a Whig banker. His best remembered works are *The Pleasures of Memory* (1792) and *Italy* (1822). The former is in rhymed couplets, the latter in blank verse, but both belong in spirit to the eighteenth century. They are the efforts of a dilettante rather than the composition of a true poet. Rogers, by his wealth, was able to be a patron of literature and a connoisseur in art. His life was devoted to the pleasures of society; he sought to be "a wit among lords and a lord among wits." His hospitality was enjoyed by all the celebrities of the time; his conversation was highly relished; though his wit was sharp, his actions were charitable.

The Pleasures of Hope, which gave early fame to Thomas Campbell (1777-1844), was suggested by Rogers' poem, but was more directly an imitation of Goldsmith's *Traveler.* In it Campbell, then but twenty-one, made a poetical survey of Europe. His spirited ballads on events of the time, "Hohenlinden" (1799), "Ye Mariners ot England" (1800), and "The Battle of the Baltic" (1809), have retained popularity, while his longer poems are neglected. Campbell, having settled in London, was constantly and remuneratively employed as miscellaneous writer, editor of biographical and critical works, and collections of poetry. His *Gertrude of Wyoming* (1809) is a tragic story in the Spenserian stanza, but the scene is laid in Pennsylvania, with which the author had no direct acquaintance. It is a conventional English tale with foreign locality, and melodramatic accessories. Campbell added to his fame by "Lochiel's Warning" and "The Exile of Erin," but not by his longer narrative poems. In 1830 he was made editor of Colburn's *New Monthly Magazine.*

Landor.—Many poets, from Coleridge and Shelley to Swinburne and Lowell, have pronounced Landor a great poet, and excellent critics regard him as an exquisite prose writer. He set himself to be an artist in language, but he is too coldly intellectual ever to win the hearts of the people. Walter Savage Landor (1775-1864) entered Rugby at an early age, and thence went to Trinity College, Oxford; but he left without a degree. His epic poem, *Gebir,* an Oriental story of no great interest, has many passages of magnificent beauty. It has been declared to have "Tennyson's finish, Arnold's objectivity, and the romance of Keats and Morris." Landor was a most eccentric, ungovernable person, married in haste, quarreled with his wife and went to Italy. Aristocratic in tastes, he was republican in principle, and gave vent to explosions of wrath against kings, critics and cooks, who were all in the wrong. He was the original of Boythorn in Dickens' *Bleak House.* His most valuable work is *Imaginary Conversations,* in the several volumes of which he professes to report discussions of important subjects by noted historic personages of ancient and modern times. In 1858, some years after his return to England, he published *Dry Sticks Fagoted,* a collection of caustic epigrams and satires. Forthwith he was overwhelmed with libel suits, from which he fled again to Italy, there to die in exile at the age of eighty-nine.

Charles Lamb.—The personal history of Charles Lamb (1775-1834) is an affecting tragedy, brightened by his genial character and generous self-sacrifice. He was educated at the famous Bluecoat school, and at an early age became a clerk in the East India House, where he remained for thirty years. The cloud of his life was the fact that his elder sister, Mary, was liable to fits of insanity, and that in one of these she stabbed her mother to the heart. For a time she was confined in an asylum, and when her sanity returned Charles was permitted to take her home. Mary was never made aware of her desperate deed, but afterward when she felt the trouble recurring, she cheerfully accompanied Charles to the asylum. While she was in mental health they lived happily "in double singleness," and had weekly gatherings of literary friends. The gentle Charles, thus precluded from marriage, was a diligent student of early English writers, while Mary amused herself with the current literature. Charles' love of the Elizabethan dramatists led him to imitate them in a tragedy, *John Woodvil.* His attempt at a farce failed at Drury Lane. Then he issued *Specimens of the Old English Dramatists,* with excellent brief introductions. They served to remind modern readers what literary treasures were concealed in the works of Shakespeare's contemporaries. With the aid of his sister, Lamb prepared for children *Tales from Shakespeare,* which are still much in request. But the *London Magazine* opened for the literary clerk the proper field for his peculiar talent. Taking the pseudonym "Elia," he poured forth freely his fanciful observations and crotchets. Lamb was essentially a Londoner, and thoroughly acquainted with the curious characters and incidents of the great metropolis. Some of these he now sketched in a delightful sympathetic manner. He was also a lover of quaint half-forgotten lore, which he recalled for the entertainment of a new generation. His quiet merriment and genuine pathos are set off by his queer, old-fashioned style. His conversation abounded in puns, the effect of which was heightened by his stuttering. His *Letters,* which have been carefully edited, are written in the same vein as the more finished essays, and prove that habit of thought to have been natural. At times he soars in the realms of fancy, but generally he keeps close to the solid earth. His "Dissertation on Roast Pig" is a classical piece of fun; "The Praise of Chimney-Sweepers" is full of humerous kindness; his "Dream-Children" and "The Child-Angel" reveal the writer's tender heart. He describes his sister fondly under the name of "Bridget Elia," and tells of his bachelor's life and mental oddities with playful frankness. The essays, written chiefly to entertain his friends, were a recreation after his daily drudgery at office work. Occasionally he ventured into poetry of some quaint fanciful kind, as in his "Farewell to Tobacco." His unrhymed "Old Familiar Faces" is deeply pathetic. One stroke more must be added to the tragedy of his life in this afflicted household. Ten years younger than his unfortunate sister, he died thirteen years before her. His friend, Thomas N. Talfourd, wrote his biography without mentioning the central tragedy in order to spare her feelings, but after her death revised the narrative to conform to facts.

Hazlitt.—Though educated to be an artist, William Hazlitt (1778-1830) devoted himself to a literary life. He has been pronounced by competent judges the greatest of English critics. He was the son of a Unitarian preacher, and, in early manhood, coming in contact with Coleridge, was powerfully affected by him. His inclination was to art, but he was drawn into newspaper work in London, became a critic of art and the drama, lectured on literature, and wrote numerous essays of all sorts. His variable temper made him difficult to get along with. He was harsh not only to his political opponents, but to those who tried to be his friends. He quarreled with his first wife, who had brought him some property, and was discreditably divorced from her. Then came a violent passion for the daughter of a lodging-house keeper, and when she refused him he told the whole story without reserve in his *Liber Amoris.* A second wife left him in a few years. Yet this restless, quarrelsome, uncertain man said when dying, at the age of fifty-two, "I have had a happy life." As a writer he shows wide experience of life, a robust intellect, and fluency in expression. His miscellaneous essays comprise many admirable sketches, as "Merry England," "Going on a Journey," "The Indian Jugglers." But his most valuable work is seen in his literary criticism, in *The Characters of Shakespeare, The Elizabethan Dramatists, The English Poets,* and *The English Comic Writers.* His intense personality caused him to have strong prejudices, so that his opinions, though sincere, should not always be accepted; but whenever he is really judicial he exhibits the highest excellence of criticism—proper and adequate estimate of the authors considered.

De Quincey.—One of the great masters of English prose was Thomas De Quincey (1785-1859). Born at Manchester, the son of a wealthy merchant, he was educated at Oxford, but being under no restraint, wandered at times to Dublin, London and elsewhere. He also acquired the opium habit, and after he settled, in 1809, at Grasmere, in the Lake district, in a house formerly occupied by Wordsworth, the use of opium, or rather laudanum, grew upon him. At this time he was wealthy, and was admitted at once to intimacy with the families of the poets already domiciled there. But when he married a servant the friendship cooled. She assisted him with the utmost devotion in his desperate struggle to free himself from the thraldom to opium, which was finally successful. He was dwarfish in stature, and, though of refined taste, careless in dress. Gradually his fortune was wasted, and the strange genius had to resort to his pen for a living. In his *Confessions of an English Opium Eater,* especially in his portrayal of scenes from his dreams, De Quincey used an elaborate semi-poetical style, partly founded on his study of music. "Our Ladies of Sorrow" and "The English Mail Coach" are fine examples of this new style. Although he did not begin to write for publication until the age of thirty-six, once started he kept it up vigorously to the end of his life. It comprised critical, narrative, biographical and autobiographic sketches. He has been charged with carelessness about personal facts, and excused on the plea that to him dreams and realities were often interchangeable. There was always an air of mystery about the curious little man. He removed to Edinburgh in 1830, and made that his chief place of residence for the rest of his life. His best writing has seldom been excelled in strength or brilliancy. He indulged also at times in a peculiar, grotesque humor, and often carried it to excess. Though not a pedant, he sometimes boasts of his learning, and seeks to display skill in needless argument. In philosophy he was a follower of Coleridge, whose ideas he presented in a more finished style. He was a searching investigator of all received opinions and a keen critic of the works of others.

JOAN OF ARC.

What is to be thought of the poor shepherd-girl from the hills and forests of Lorraine, that—like the Hebrew shepherd-boy from the hills and forests of Judea—rose suddenly out of the quiet, out of the safety, out of the religious inspiration rooted in deep pastoral solitudes, to a station in the van of armies, and to a more perilous station at the right hand of kings? The Hebrew boy inaugurated his patriotic mission by an *act,* by a victorious act such as no man could deny. But so did the girl of Lorraine, if we read her story as it was read by those who saw her nearest. Adverse armies bore witness to the boy as no pretender: but so they did to the gentle girl. Judged by the voices of all who saw them from a station of good-will, both were found true and loyal to any promises involved in their first acts. Enemies it was that made the difference between their subsequent fortunes. The boy rose to a splendor and a noon-day prosperity, both personal and public, that rang through the records of his people, and became a by-word amongst his posterity for a thousand years. The poor forsaken girl, on the contrary, drank not herself from that cup of rest which she had secured for France. She never sang together with them the songs that rose from her native Domrémy, as echoes to the departing steps of invaders. She mingled not in the festal dances at Vaucouleurs which celebrated in rapture the redemption of France. No! for her voice was then silent. No! for her feet were dust.

Pure, innocent, noble-hearted girl! whom, from the earliest youth, ever I believed in as full of truth and self-sacrifice, this was amongst the strongest pledges for *thy* side, that never once—no, not for a moment of weakness—didst thou revel in the vision of coronets and honors from man. Coronets for thee! O no. Honors, if they come when all is over, are for those that share thy blood. Daughter of Domrémy, when the gratitude of the king shall awaken, thou shalt be sleeping with the dead. Call her, King of France, but she will not hear thee! Cite her, by thy apparitors, to come and receive a robe of honor, but she will be found *en contumace.* When the thunders of universal France, as even yet may happen, shall proclaim the grandeur of the poor shepherd-girl that gave up all for her country—thy ear, young shepherd-girl, will have been deaf for five centuries. To suffer and to do, that was thy portion in life; to *do*—never for thyself, always for others; to *suffer*—never in the persons of generous champions, always in thy own: that was thy destiny; and not for a moment was it hidden from thyself. "Life," thou saidst, "is short, and the sleep which is in the grave is long; let me use that life, so transitory, for the glory of those heavenly dreams destined to comfort the sleep which is so long."

This pure creature—pure from every suspicion of even a visionary self-interest, even as she was pure in senses more obvious—never once did this holy child, as regarded herself, relax her belief in the darkness that was traveling to meet her. She might not prefigure the very manner of her death; she saw not in vision, perhaps, the aërial altitude of the fiery scaffold, the spectators without end on every road pouring into Rouen as to a coronation; the surging smoke, the volleying flames; the hostile faces all around; the pitying eye that lurked but here and there until nature and imperishable truth broke loose from artificial restraints:—these might not be apparent through the mists of the hurrying future. But the voice that called her to death, *that* she heard forever.

Women Writers.—The nineteenth century has been distinguished by the number and excellence of its women writers. The first of merit still acknowledged is Maria Edgeworth (1767-1849). Her *Castle Rackrent* (1801) is a lively picture of the recklessness and misconduct of Irish landlords. Her *Belinda* (1803) exhibits the female dissipation of the same time. *Helen* is a story of thrilling interest, showing the miseries of deceit. *The Absentee* reveals the wretchedness inflicted on the Irish tenantry by unscrupulous agents, while the gentry pursue their pleasures in London. When Miss Edgeworth visited Sir Walter Scott, in 1823, he said that her stories had made him wish to do for Scotland what she had done for Ireland. But this may have been only the baronet's gallantry to a lady author. Treating only of Protestant society, and dealing but sparingly with the peasantry and middle classes, her stories were not thoroughly national, yet she depicted a variety of types and set them off with humor. Her chief excellence is in sprightly dialogue and amusing scenes. Her short moral tales are better than her long novels.

Another woman, less popular in her day, but now regarded as having a higher genius, was Jane Austen (1775-1817), a country clergyman's daughter. Her first publication was *Sense and Sensibility* (1810), but she is said to have written novels many years before. She had no literary companionship, yet in spite of her secluded life and slender knowledge of society, she succeeded in creating many real characters. Her skill lay in building them up with an infinity of detail. Her talent for describing the involvements and feelings of ordinary society won Scott's admiration. Her delicate irony is rare among women, and gives her a modern tone. Two of her six novels were published after her death. The best are *Emma* and *Pride and Prejudice.*

Susan Ferrier (1782-1854), an Edinburgh lady, published three novels anonymously—*Marriage* (1818), *The Inheritance* (1824), and *Destiny* (1831). Sir Walter Scott praised their clever portraiture of contemporary Scotch life and manners, and called her, with reference to their common anonymousness, his "sister shadow." She did for Scotland what Miss Edgeworth did for Ireland and Miss Austen for England.

Even more popular than these novelists was the poet Felicia Dorothea Hemans (1794-1835), whose verses won praises from the leading poets, as Wordsworth, and critics, as Jeffrey. Being a woman of wide culture, she ranged over Europe, seeking subjects for pathetic dramas, romantic tales, and songs of the affections. Many of her poems, as *Casabianca, Bernardo del Carpio, The Burial of William the Conqueror,* and *The Better Land,* have been widely diffused through school books. The religious tone of her poetry, which descanted on the transitoriness of this life and the assured hope of a better world, commended it to the favor of many readers. She had been unhappy in her marriage with Captain Hemans, and was compelled to write for the support of her children. After her death a collective edition of her poems occupied seven volumes.

Hood.—Among the contributors to the *London Magazine* was one who "learned in suffering what he told in song." Thomas Hood (1798-1845) is best remembered by his *Bridge of Sighs* and *The Song of the Shirt,* but he was also a noted humorist and an inveterate punster. He had been trained for business, but the failure of the firm in which he had an interest so involved him that he went to Germany for five years to endeavor, by economy, to pay off these involuntary debts. On his return to London he became editor of *The New Monthly Magazine.* His health was precarious, and he continued to work with his pen when unable to rise from his bed. A year before his death the government allowed him a pension. Some of his poems and most of his prose are sheer fun; others are a mingling of humor and pathos; but the best are purely pathetic. His most elaborate poems, *Plea of the Midsummer Fairies* and *Hero and Leander,* abound in beautiful descriptions of nature. While for the sake of immediate gain he poured out *Whims and Oddities,* and with his *Comic Annual* kept the world laughing, his heart was thoroughly sensitive and his fancy was delicate. No impurity smirched his work. Besides the poems already mentioned, the most deserving are *Eugene Aram, Love's Eclipse,* and the touching verses, *The Death-bed.*

Keble.—What has been called the Tractarian, or Puseyite or Oxford movement in the Church of England was started by a sermon preached at Oxford in 1833 by Rev. John Keble (1792-1866). It was a protest against Catholic emancipation, that is the granting to Roman Catholics the right to sit in Parliament. Keble regarded this act as a renunciation of the claims of the Established Anglican Church to a divine prerogative. The movement took shape in the publication of a series of *Tracts for the Times.* These *Tracts,* written chiefly by John Henry Newman and E. B. Pusey, set forth Catholic doctrines as the true faith of the English Church, but their Romeward tendency was so marked that after reaching No. 90 their continuance was prohibited. Keble had been prominent at Oxford while a student and a fellow. But when he was ordained he retired to a country curacy, though on various occasions he was called back to perform some special duty. The chief fruit of his meditative life was the collection of poems called *The Christian Year* (1827). It has been accepted as the best poetic expression of the devotional feelings of the Anglican Churchman. After his comrade, Newman, entered the Catholic communion, Keble joined with Dr. Pusey in defending the position and principles of the English Church, but only his early poems have won popular acceptance.

Hallam.—Among the historians who are more praised than read, Henry Hallam (1777-1859) holds a prominent place. He was son of a dean and a graduate of Oxford, but a Whig in politics, and an early contributor to the *Edinburgh Review.* Wealth of learning and soundness of judgment were shown in his *View of the State of Europe in the Middle Ages* (1818), but the style was too formal and dignified. This work really forms an introduction to his next, *The Constitutional History of England from the Accession of Henry VII to the Death of George II* (1827). Here the author shows more direct interest in his subject, and awakes more in an intelligent reader. While firmly believing in the benefits of the progressive changes, he holds an eminently judicial attitude in describing the conflicts of statesmen and parties. His third work, *An Introduction to the Literature of Europe in the Fifteenth, Sixteenth and Seventeenth Centuries* (1839), is less satisfactory. He was rather a historian of externals than a critic of imaginative achievements. Yet the work, being based on careful study, was excellent in its way. All his works are characterized by a judicial impartiality which gives value to his decisions.

Other historians of good repute flourished in this period; among them Rev. John Lingard (1771-1851), the fair-minded, diligent Catholic historian of England; Thomas Arnold (1795-1842), the renowned head-master of Rugby, whose *History of Rome* recited Livy's picturesque stories in an antique style befitting legends, and discussed the buried facts in more modern style; Dean Henry Hart Milman (1791-1868), who wrote a *History of the Jews* (1829), showing a liberal spirit, and a *History of Latin Christianity* (1855), in which he traversed the same ground as Gibbon in his great work; Bishop Connop Thirlwall (1797-1875), whose accurate but rather dry *History of Greece* (1845-52) had the misfortune to be eclipsed by Grote's better work.

Grote.—The career of George Grote (1794-1871) is remarkable. The son of a banker, he was taken from the Charterhouse school and put into the bank at sixteen. Yet such was his love of philosophy and devotion to learning that he devoted his leisure to study. William Mitford (1744-1827), an ardent Tory, had, by the advice of Gibbon, written an elaborate *History of Greece* (5 vols., 1784-1818), which exhibited the evils and miseries of its democratic government as a permanent warning to mankind. Grote, who was a philosophic radical, dissented from this view, which was generally approved, and determined to write the story in a different spirit. For years he gathered the material and labored at the work. At the same time he conducted the banking business which he had inherited, and also entered Parliament. In spite of these and other demands on his time he began to publish his *History of Greece* in 1846, and completed it in twelve volumes in 1856. By that time he had withdrawn from Parliament, but he kept up his Greek studies, and published *Plato and Other Companions of Socrates* (1865). After his death his unfinished treatise on Aristotle was edited and published by his friends. Grote's work still remains the standard history of Greece, and excites wonder by the fact that one who had no advantage of university education had so surpassed professional students in the subject to which their lives were dedicated. Not only in general estimate of men and events, but in minute points of scholarship, he corrected them repeatedly, as they were obliged to admit.

Disraeli (Lord Beaconsfield).—Forever unique in English history and literature is Benjamin Disraeli (1804-1881), who, after an astonishing political career, full of stormy fights and glorious victories, became Earl of Beaconsfield. He was of Spanish-Jewish descent, but his grandfather, Benjamin, a London banker, had withdrawn from the synagogue. His father, Isaac Disraeli, was a quiet, plodding scholar, who wrote the rambling *Curiosities of Literature* and similar compilations. Benjamin early displayed a widely different character from his father, being conspicuous among the dandies who frequented the drawing rooms of the fascinating Irish Countess of Blessington. In 1826 London was amazed and delighted by his dazzling political novel, *Vivian Grey,* which not only satirized piquantly the leaders of the time and discussed political problems seriously, but even prefigured his own career. It quite eclipsed his fellow-dandy Bulwer's *Falkland,* which had just appeared. After three years' tour in the East Disraeli published *Contarini Fleming* (1832), showing the development of a poetic character and giving brilliant sketches of Italy and Syria. Then came the *Wondrous Tale of Alroy* (1833), a dithyrambic Oriental romance of a mediæval Messiah. *The Revolutionary Epick* (1834), eulogized tyrannicide in blank verse, but disappointed the author by attracting no attention.

Meantime Disraeli had been trying to get into Parliament as a Radical. After two defeats he turned quite round and gave efficient help to the disheartened Tory party by his *Runnymede Letters* (1836), defending the British Constitution against Whig innovations. Yet he always retained much of his early Radicalism, and eventually compelled the reluctant Tories to accept some of it in order "to dish the Whigs." Other books were issued before he reached Parliament—*Henrietta Temple,* a very sensational love story, and *Venetia,* which was based on Byron's life. No English writer has surpassed Disraeli in transferring the prominent characters of the time into fiction with little alteration of character.

At the age of thirty-two the persevering Disraeli entered Parliament, but his maiden speech was a deplorable failure. When hooted down he cried with dauntless courage, "I shall sit down now; but the time will come when you will hear me." In 1839 he married the wealthy widow of his friend, Wyndham Lewis, whom he afterward praised as a perfect wife. A political literary group was formed under the name "Young England," and Disraeli expounded its principles in *Coningsby; or, The New Generation* (1844). *Sybil* (1845), his next story, treated of the Chartist agitation. *Tancred; or, The New Crusade* (1847), was a further exposition of the political views he was urging on the Conservative party. Being now a prominent speaker in Parliament, he fiercely assailed Sir Robert Peel for his adoption of Free Trade. When the Tories returned to power in 1852, Disraeli was their leader in the House of Commons. Increased political duties prevented his giving time to literature. He first became Prime Minister in 1868. Two years later, while out of office, he published *Lothair,* a brilliant presentation of the religious as well as the political tendencies of the time. Its historical basis was the winning of the Earl of Beste to the Roman communion, but the novel, while depicting graphically the conflict, gave a different conclusion.

In 1872 Disraeli suffered the loss of his wife, who had gloried in his triumphs and lightened his reverses. In 1874 he regained political supremacy, and two years later he accepted the apotheosis of the peerage. The Berlin Congress of 1880, which readjusted the results of the Russo-Turkish War, was the crowning triumph of his career. Yet another was his inducing Parliament to confer on Queen Victoria the title of Empress of India. The veteran statesman died in April, 1881. His last novel, *Endymion* (1881), presented, after his usual fashion, Lord Palmerston, Louis Napoleon (as a young man) and other celebrities.

The acrobatic career of Lord Beaconsfield is more romantic than his novels, brilliant as they are with epigram and paradox. His style was highly rhetorical and sometimes tawdry. In spite of occasional glaring plagiarisms in speech and writing, his overwhelming originality could not be denied. His frequent presentations of living characters under thin disguises piqued curiosity; yet the real value of his work lay elsewhere—in the keen, forceful discussion of the social and political problems of England. Under a veil of irony a sufficient amount of permanent truth could be discerned.

Carlyle.—Amid the throng of historians and essayists of this period one stands conspicuous whose mission was rather that of a Hebrew prophet to denounce and bewail the sins of his people. Thomas Carlyle (1795-1881) was the eldest son of a poor Scotch farmer, who made sacrifices to prepare him for the ministry in the Secession Church. Thomas was educated at the Edinburgh University, became a schoolmaster and tutor, but after profound soul-struggles turned his back on the kirk and devoted himself to literature. Being well versed in German, he wrote articles on its literature for the *London Magazine* and other periodicals. This study, as well as his peculiar mode of thought, gradually affected his style, which became strangely introverted and exclamatory. In 1826 he married Jane Welsh, a woman of noble spirit and intellectual taste. But their poverty could give them shelter only on a barren farm in a wild moorland district, which he called "the loneliest spot in Britain." Carlyle had already published a *Life of Schiller* (1824) and translated Goethe's *Wilhelm Meister* (1824), hoping to give English readers a just opinion of the powers of the great German, with whom he now entered in correspondence. He published translations of *German Romance* (1827 and wrote regularly for the *Edinburgh Review,* still chiefly on German subjects, but also on the Scotchman's favorite, Burns.

But Carlyle's heart was still meditating on his own life-problem, and in 1830 he gave vent to his musing in *Sartor Resartus,* whose title is but a Latin rendering of that of a Scotch song, *"The Tailor Done Over."* It professed to be a review, with ample quotations, from a book written by a German professor, Diogenes Teufelsdröckh (God-sprung Devil's-dung), on Clothes philosophy. The astounding German name indicated his estimate of mankind. The discussion of clothes was a series of satirical comments on the various ways in which the human spirit manifests itself. The grotesque conglomerate was promptly rejected by the London publishers, and not until 1833 did it appear serially in *Fraser's Magazine,* to the dismay of the regular subscribers, who were loud in their protests. But the new voice found echo in the world, and multitudes studied its utterance. Yet not until 1838 was the strange philosophy put in book-form.

In 1834 Carlyle removed to London, where he found a home for the rest of his long life. His next book was *The French Revolution* (1837), which professed to be a history, and was founded on a thorough study of all the materials then accessible, but was really a prose poem of the spectacular scenes and characters of that tremendous upheaval. Turning to the agitation then prevailing in England, Carlyle next discussed *Chartism* (1839), showing contempt for the blind action of the masses seeking reform, and insisting on government of the brute herd by the despotism of the benevolent strong man whom it is the duty of each age to discover for itself. His work *On Heroes, Hero-Worship and the Heroic in History* (1841) was a nobler expression of broad sympathy with the greatest leaders of the human race. From Scandinavian mythology he took Odin as the hero raised to be a divinity; from the East he selected Mahomet as the prophet-hero; in Europe he chose Dante and Shakespeare as the poet-heroes; Luther and Knox as the priest-heroes; Johnson, Rousseau and Burns as literary heroes, Cromwell and Napoleon as the hero-kings. One great English hero he went on to redeem more completely from the reproach which Hume and others had unjustly cast upon this Protector by publishing *Oliver Cromwell's Letters and Speeches; with Elucidation* (1845). Here was indeed a shock to the conservative adherents of monarchy, who had long been content with Clarendon's prejudiced portrait of the daring usurper of the English throne. In the *Latter-day Pamphlets* (1850) Carlyle carried to violent extreme the ideas he had already broached in *Chartism.* He ridiculed and denounced all humanitarian movements and eulogized coercion as the panacea for social evils.

Carlyle's *Life of John Sterling* (1851) was a tribute of friendship to the memory of a man who, like himself, and through his counsel, had forsaken the Church for literature. It was also a reply to Rev. Julius Hare, who had treated the subject from a different standpoint, yet with no unfriendly spirit. But Carlyle indulged in shameful slanders of Coleridge and the clergy. At last Carlyle undertook his longest work, *The History of*

Frederick the Great, and gave fourteen years to its accomplishment. It was completed in 1865, having reached six volumes. Frederick was indeed a notable type of the strong man who overcomes all obstacles, achieves his own ends and controls the destinies of others. Yet he was not morally great, and Carlyle, in the course of his work, shows consciousness of his hero's unworthiness. Carlyle's defect as a historian is his lack of discernment or regard for collective national life. His gaze is fixed on the individual, on the incarnation of force; he sees not the continued development of a nation, much less of humanity as a whole. Resolutely to the end of his great work the historian toiled, though sick of his task. Two years after it was done he growled, "Let it now wander into the belly of oblivion forever."

There remained the veteran a notable triumph when he was chosen Lord Rector of the University of Edinburgh, and in April, 1866, delivered his memorable installation address. It was a hopeful summary of his views of human life and duties, and was received with acclamation. But his joy was marred by the loss of his wife, who died suddenly before his return to London. In his *Reminiscences,* not published till 1881, by his friend Froude, he bewailed the calamity in passionate terms which led to much misunderstanding of the affection with which he had always regarded and treated her. His valuable and characteristic work had been accomplished before her death. His *Shooting Niagara—and After?* poured a deluge of contempt on Disraeli's sudden extension of suffrage in 1867. His *Early Kings of Norway* (1875) was a weak performance. His last publication was a discussion of *The Portraits of John Knox.*

Unfortunately for Carlyle's fame an unpleasant controversy arose from the action of his literary executor, the historian Froude, in publishing not only the *Reminiscences,* but also a *Memoir,* coming down to 1835, and *Mrs. Carlyle's Letters* (1883). Froude had been authorized to publish such writings as he thought proper, and he deemed it right to let the whole story tell itself. He was charged, however, with carelessness or incompetence in many misreadings of the manuscripts. But still worse were the gross misinterpretations of many passages which should have been explained or suppressed. The censorious prophet began to be regarded as a wild beast, unfit to associate with human kind. Froude defended himself as best he could, alleging the honesty of his intentions. Other writers made needed corrections in the letters, and the hot dispute gradually simmered down. Between Emerson and Carlyle there had sprung up a friendly esteem which led to each publishing in his own land the works of the other, with words of preface and commendation. Their *Correspondence* (published in 1883) proves their mutual regard.

Carlyle's works are stimulating, suggestive and inspiring in parts, but they are also full of glaring inconsistencies. The most striking of all is his constant talk and writing contrasted with his continual plea for silence, his call on men to do something and not talk about it. One of the best of his minor works is *Past and Present* (1843), in which he makes the simple story of Abbot Samson, of the twelfth century, a text for reproval of men of the nineteenth. Had he never gone further than this in rebuke he might have been more readily heard. But the general tendency of the world, both of thinkers and actors, has been away from the extreme worship of the strong man, persistently advocated by Carlyle. Though his wanton sneers at the intelligence of the people have diminished the number of his disciples, his severely stern denunciation of shams of all sorts and his insistence on sincere regard for the eternal verities have undoubtedly been beneficial.

DO THY DUTY.

(From *Sartor Resartus.*)

Most true it is as a wise man teaches us, that doubt of any sort cannot be removed except by action. On which ground, too, let him who gropes painfully in darkness or uncertain light, and prays vehemently that the dawn may ripen into day, lay this other precept also well to heart, which to me was of invaluable service:—Do the Duty which lies nearest thee, which thou knowest to be a Duty. The second duty will already have become clearer. May we not say, however, that the hour of spiritual enfranchisement is even this? When your ideal world, wherein the whole man has been dimly struggling and inexpressibly languishing to work, becomes revealed and thrown open, and you discover with amazement enough, like the Lothario in Wilhelm Meister, that your America is here or nowhere. The situation that has not its duty, its ideal, was never yet occupied by man. Yes, here in this poor, miserable, hampered actual wherein thou even now standest, here or nowhere, is thy Ideal; work it out therefrom, believe, live and be free. Fool! the Ideal is in thyself; the impediment, too, is in thyself. Thy condition is but the stuff thou art to shape that same ideal out of. What matter whether such stuff be of this sort or that, so the form thou give it be heroic, be poetic? O, thou that pinest in the imprisonment of the actual, and criest bitterly to the gods for a kingdom wherein to rule and create, know this of a truth, the thing thou seekest is already with thee, here or nowhere, couldst thou only see.

Marryat.—By his tales of nautical adventure, Captain Frederick Marryat (1792-1848) won peculiar distinction. Though his father was a wealthy London merchant and member of Parliament, little Fred ran away to sea, and at the age of fourteen he was allowed to enter the navy. Serving under the daring Cochrane (afterwards Lord Dundonald) off the coast of South America, he witnessed fifty engagements in thirty months. Marryat was highly commended for valor in war and humanity in peace, and was distinguished as post-captain in the Burmese war of 1824-25. After more than twenty years' experience of sea life, Marryat began to describe it in 1829. His first novel, *Frank Mildmay,* was but a thinly disguised rehearsal of the adventures of Cochrane and his crew. *The King's Own* is more artistic, and contains a powerful dramatic scene in which the captain sacrifices the frigate Aspasia in order to wreck a French line-of-battle ship on a lee shore.

Having proved his literary gift, Marryat retired from the naval service in 1830 and produced in rapid succession *Newton Forster, Jacob Faithful, Japhet in Search of a Father,* and *Midshipman Easy. Peter Simple* is the most popular, and furnishes a lively succession of amusing occurrences. But *Snarley-yow* ranks higher for humorous portraiture and richness of incident. In 1832 Marryat became editor of the *Metropolitan Magazine.* He produced more stories, some relating to the land and some, as *Masterman Ready,* intended for juvenile readers. Marryat's books, like most sea stories, show a certain ferocity and fondness for practical jokes. In them can be seen the terrible hardships and heroic actions, as well as the light-hearted fun of the sailor's life.

Lever.—The military novels of Charles Lever (1806-1872) bear strong resemblance to the nautical novels of Captain Marryat. Both authors endow their characters with exuberant animal spirits and furnish a rapid succession of amusing and exciting incidents. But Lever changed his style of writing more than once in his career. He was the son of an English architect, but was born in Dublin and educated in Trinity College of that city. As a physician he displayed courage and skill in several parts of Ireland during the epidemic of cholera in 1832. After his marriage he went to Brussels and practised among the British residents. From his own experience and the entertaining stories of retired officers who had served in Spain he gathered the material of *The Confessions of Harry Lorrequer, The Adventures of Charles O'Malley,* and *Jack Hinton, the Guardsman.* Careless in plot, but full of boisterous good humor, these novels describe fighting and battle-scenes with vigor. All classes of military men figure in them, from the Duke of Wellington to the reckless Micky Free. While editor of *The Dublin University Magazine,* from 1842 to 1845, Lever published *Tom Burke of Ours, The O'Donoghue, The Knight of Gwynne.* They exhibit the volatile side of Irish life and a racy national humor.

In later life Lever was British Consul at Carlsruhe, in the Tyrol, at Spezzia, and finally at Trieste. In the novels of this period he described English travelers or residents on the Continent. Among them are *The Daltons, The Dodd Family Abroad, Davenport Dunn.* He wrote also for *Blackwood's Magazine* miscellaneous papers under the name of *Cornelius O'Dowd.* His latest novels were the best constructed, but the vigor of his invention and humor had been already spent, so that they never reached the popularity of his early ones.

Kingsley.—Charles Kingsley (1819-1875) was called the apostle of muscular Christianity, but his life was singularly uneventful. He was born at Dartmoor, Devon, where his father was an old-fashioned fox-hunting rector. He went to Cambridge, took honors, and was ordained. For thirty-four years he was curate and rector at Eversley, a country village. His first book was *The Saint's Tragedy* (1848), a drama on the story of St. Elizabeth of Hungary. Being roused by the Chartist movement and the writings of Carlyle to the necessity of righting the wrongs of the oppressed, he joined with Rev. F. D. Maurice in an effort to make Christianity practical among the masses. His sympathy with working men was shown in *Alton Locke* (1850), the pathetic story of a London tailor who took part in the Chartist insurrection. His next story, *Yeast* (1851), made the stir of the time appear as a struggle towards a better life. In *Fraser's Magazine* he treated of a variety of subjects from literature to fishing. *Hypatia; or, New Foes with an Old Face,* was his first historical novel. It presents a vivid panorama of Alexandria in the fourth century and the struggle of Christianity with Pagan philosophy and other foes, virtually the same as those in the England of Queen Victoria. Hypatia, slain by a fanatical Christian mob, was the martyr maid of philosophy. Kingsley's next novel, *Westward Ho!* (1855), generally considered his masterpiece, recalled the Elizabethan adventurers, Raleigh and Drake. *Two Years Ago* (1857) dealt with the Crimean War. *Hereward the Wake* (1866) went back to the Saxon times. Throughout these historical novels the landscapes and sea scenes are finely depicted. The more remote they are the more care is taken to render them pictorial. The poem, *Andromeda* (1858), one of the best examples of hexameter verse in English, treats of the Greek myth of Perseus. *The Water Babies* (1863) is a charming fairy tale for children, yet may be considered a pleasant satire by adults. Some of Kingsley's short poems are universal favorites, especially *The Three Fishers.*

Bronte.—A strangely pathetic story is that of the Bronte family. Rev. Patrick Bronte, an eccentric Irishman, had become parson of a moorland parish in Yorkshire. His three daughters, brought up in dire poverty in this dreary wilderness, had intense longings for advantages beyond their reach. In order to become qualified as governesses Charlotte (1816-1855) and Emily spent a year in Brussels. After their return the three sisters published a volume of poems, under the assumed names Currer, Ellis and Acton Bell. The literary instinct was strong, and they resolved to write each a story. Charlotte's attempt, *The Professor,* could not secure a publisher. Then she set to work on *Jane Eyre,* which, after being refused by several publishers, was at last accepted and issued in 1847. It is the story of a plain orphan girl, educated by charity, who enters the household of Edward Rochester, a rough, domineering master, whose insane wife is kept in concealment. This man, who had already been sated with the worldly excitements, becomes, to his own surprise, interested in the little, plain, but intelligent woman, who evidently tries to avoid his attentions. The book revealed in circumstantial detail much of the author's experience, and her deepest feelings. The reading public were struck with the singular exhibition of a woman's nature. Charlotte was summoned to London to meet the literary magnates, but the shy little woman soon returned to her moorland home. Her second book, *Shirley* (1848), was more labored than the first, and shocked some readers by making her heroine seek too eagerly for the man of her choice. *Villette* (1852) was based on her experience in Brussels. The description of the love of the vivacious French professor, Paul Emmanuel, for the modest little English girl, Lucy Stowe, was a new triumph for the author. In 1854 Charlotte was married to her father's curate, Mr. Nicholls, but she died within a year. Her sister, Emily (1818-1848), had written a fiercely tragic novel, *Wuthering Heights,* and some short poems of strong feeling. Not one of the three sisters reached the age of forty.

The strange biography of the Bronte family was written by Mrs. Elizabeth Gaskell (1810-1865), herself a novelist of merit. Her first story, *Mary Barton* (1848), was a pathetic delineation of some scenes of Manchester life. *Ruth* (1850) was a story of the redemption of a too trusting girl who had been seduced by a villain. But the most noted of Mrs. Gaskell's works is *Cranford,* a pleasing chronicle of the simple events of a quiet village.

CHAPTER IX.

From Wordsworth's Death to the Twentieth Century.

A. D. 1851—1904.

The Nineteenth Century was distinguished by immense material progress, by a wonderful advance in every branch of science, and by new and strange applications of its discoveries to human welfare. It is not surprising, therefore, that Carlyle and other prophets should utter warnings against the danger and the triumph of materialism, against the loss of faith in the invisible world and in God himself. But it is not necessary here to dwell on the corresponding activity in religion, testified by vigorous conflicts both within the Church and against its external foes. A survey of the literary achievement of England in this century gives sufficient answer to these prophets of woe.

Poetry.—In the former period the Romanticism of Scott and Byron gave way to the serene genius of Wordsworth and witnessed the rise of Tennyson. The present period may be called the age of Tennyson and Browning. From the former all the minor poets learned the art of combining exquisite sweetness with lucid clearness and strict observance of metrical rules. Browning's deliberate refusal to submit to such restraint long hindered recognition of his genius. While this has been finally acknowledged, he has had no followers. But besides these potent sovereigns there have been in the Victorian period many excellent poets of lower rank. Swinburne was able to enrich English literature with imitations of Greek models, as well as with original luscious poetry in various metres. Matthew Arnold, by his closer adherence to classical forms and style, confined his poetry to a select few, but by his criticism he improved the tone of prose. William Morris went back to Arthurian romances and Scandinavian sagas for material, which he wrought into poems of striking beauty. The pessimism of the age found poetical expression in Fitzgerald's translations of Omar Khayyam. The century closed with the advent of Kipling, who elevated the songs of the camp and music-hall into thrilling ballads.

History.—In the large domain of history much has been accomplished in this period. Freeman exhibited at length the *Norman Conquest of England*, and made wide excursions into the history of other countries, ending with an unfinished *History of Sicily*. Froude treated with similar fulness, but less exactness, the momentous period of the English Reformation, and also, in slighter works, the wide expanse of the British empire. But Bishop William Stubbs and Samuel R. Gardiner have, by faithful exploration of documents, given new aspect to many portions of English history. John Richard Green, in his *Short History of the English People*, showed that interest could be aroused by exhibiting the actual condition of the people in successive ages, as well as by brilliant pictures of courts and battles.

Essays.—The quarterly review of the former period has given way to the brisker monthly and sprightly weekly of the new period. While the *Edinburgh* and *Quarterly* still survive in a green old age, the public attention has been rather given to such periodicals as Thackeray's *Cornhill* and Dickens' *Household Words*. To these succeeded *Macmillan's Magazine* and the *Fortnightly* and *Contemporary* reviews. In these and similar periodicals science and philosophy have been popularized. In fact, every Englishman who had any message for immediate delivery to his countrymen found these the popular medium. Macaulay had taught the writers to give point and emphasis to their writings. Yet there were others, as Ruskin, who used a grand, impassioned prose style and secured attention from an ever-widening circle of readers.

Novels.—But the predominating feature of later literature has been the novel. Even in its best form it has never been recognized as belonging to the highest class of literature. But its universal acceptance has caused moralists and others who have wished to impress the public to resort to this device. Hence all religious and social, and even scientific, problems have been presented to the people in this guise. But the true domain of the novel is in the artistic presentation of life and character. To this period belong the novels of George Eliot and Charlotte Bronte, attesting the advance of women in the realm of literature. Here also belong many of the novels of Dickens and Thackeray, whose careers began earlier and were, therefore, treated in the previous chapter. Anthony Trollope was a prolific and popular novelist, but his vogue seems to have ceased. He treated only the well-to-do class, without entering deeply into their characters. In the new field of the short story no writer had greater success than Kipling, who revealed the artistic value of Tommy Atkins, as well as the many-colored life of India.

Tennyson.—The most completely representative poet of the Victorian era is Alfred Tennyson (1809-1892), who from 1851 was poet laureate of England, and from 1884 was Baron Tennyson of Aldworth and Farringford. He was born at Somersby, in Lincolnshire, where his father was rector of a church. His genius found early expression, and in 1826, with his brother Charles, he published *Poems by Two Brothers*. Alfred was educated at Trinity College, Cambridge, where he belonged to the literary coterie called "The Twelve Apostles." His most intimate friend, Arthur Henry Hallam, son of the historian, was also a member. In 1829 his poem *Timbuctoo* won the chancellor's medal, but was afterward disregarded by its author. He left the University without taking a degree. His *Poems Chiefly Lyrical* (1830) was a volume of promise, but the small one which next followed showed decided progress. It contained *The Lady of Shalott, Oenone, The Lotos-Eaters, The Palace of Art*, as well as scenes of distinctly English life, *The Miller's Daughter, The May Queen*, and *New Year's Eve*. These were marked with sweetness and a refined musical taste, and showed intimate acquaintance with ancient Greek poetry, as well as with the Arthurian legend, for which he was ultimately to do so much.

In 1832 his gifted friend Hallam died suddenly at Vienna. This affliction weighed heavily on the poet's spirit for years, during which he pondered on the mysteries of life and death, and from time to time gave utterance to his musings in elegies which, when collected, form the noble monument *In Memoriam* (1859). Its stanza of four lines had seldom been used before, but it now is recognized as the most appropriate vehicle for solemn meditations. The poem expresses not only natural impassioned grief for a departed friend, but enters deeply into the problems of immortality and Christian faith. It is an artistic, chastened expression of the longings and wrestlings of the human soul.

Before this grand poem was allowed to appear Tennyson had published others in 1842. Among them were *Ulysses*, showing continued study of Greek; *Morte d'Arthur*, a versification of Sir Thomas Malory and foretaste of the later idylls; *Locksley Hall*, a gloomy, almost pessimistic expression of the problems of the age; *The Two*

Voices, which gave the answer to skepticism. It was these that first gave, even to clear-sighted critics, assurance of Tennyson's superiority among many aspirants. *The Princess* (1847) was his first long poem in blank verse. The outline of the story seemed almost a burlesque. A king's daughter sought to emancipate her sex from man's control by founding for them a separate women's college, from which men were to be excluded; yet even within these guarded precincts love finds its way, and the heroine herself yields to the wooing of a chivalrous, dreamy prince. But the story is told so charmingly and is interspersed with such delightful songs that it was received with universal favor.

In the same year that he received the laureateship, Tennyson was married to Miss Emily Sellwood, who was admirably adapted to be a poet's wife. In 1852 Tennyson gave noble utterance to England's mingled grief and glory in the stately *Ode on the Death of the Duke of Wellington.* Two years later his *Charge of the Light Brigade* was a forceful tribute to the private soldier. *Maud* (1854) was a lyrical monologue, a remarkable expression of the power of pure love to redeem man even from madness and misanthropy.

In 1859 *The Idylls of the King* began to appear. When completed, in 1885, the epic was found to consist of twelve idylls in harmonious blank verse, each relating an incident in the story of King Arthur. While founded on Sir Thomas Malory's prose story, it does not strictly adhere to the legend as then related, and in spirit it often departs widely from the original, transferring to barbarous Britain the sentiments of the nineteenth century. Tennyson, in fact, often had in view the Prince Consort Albert when describing King Arthur. The poems are romantic tales of court and field, of love and knight-errantry, with underlying ethical motive.

At various intervals other poems appeared, some in blank verse, as *Enoch Arden* (1864), in which an English wife, supposing her sailor husband lost at sea, is wedded to another, and the rightful husband returns after some years, but shrinks from disturbing her domestic peace; others were *Ballads* (1880), vigorous or tender; and others new versions of Greek story, such as *Tiresias* (1885) and *Demeter* (1889). *Locksley Hall Sixty Years After* (1886) preserves the pensive metre of its namesake, but is more hopeful in its outlook. To the end of his long life the poet continued to polish and improve the poems he thought worth preserving. He was always minutely careful in his choice of words as he had been in choice of metres. In a few instances he showed power to use the dialect of his native Lincolnshire to give lively expression to the character of the northern farmer. His last poem, *Crossing the Bar,* expressed in modest tone his Christian confidence in death. *The Death of Oenone* was published posthumously. The title of nobility which he accepted in 1884 he had previously declined.

Tennyson, even beyond Shelley and Keats, was the master of a sweet musical style. He varied his metres to suit the sentiment or subject of his pieces. His brief lyrics are among the most perfect in all literature. His power of expressing the most delicate emotions of the heart is unsurpassed. His love of external nature is testified by his minutely exact description of its phases and phenomena. Many poems express the feelings of persons of different classes, from the child to the warrior or philosopher. Other poems recognize the scientific discoveries and the philosophic problems of the age and use them for poetic purposes. Tennyson's poems teach pure love, steadfast patriotism, self-control, belief in immortality, the sense of the Divine presence and faith in Divine goodness. Although he wrote poems of doubt and spiritual conflict expressing the wavering spirit of the age, he added to them poems of hope and assurance, evincing his final convictions. He was a clear-voiced prophet, not of lamentation or fierce denunciation, but of faith, hope and love, and of the triumph of the Kingdom of God.

ULYSSES.

It little profits that an idle king,
By this still hearth, among these barren crags,
Match'd with an aged wife, I mete and dole
Unequal laws unto a savage race,
That hoard, and sleep, and feed, and know not me.
  I cannot rest from travel: I will drink
Life to the lees: all times I have enjoy'd
Greatly, have suffer'd greatly, both with those
That loved me, and alone; on shore, and when
Thro' scudding drifts the rainy Hyades
Vext the dim sea: I am become a name;
For always roaming with a hungry heart
Much have I seen and known; cities of men
And manners, climates, councils, governments,
Myself not least, but honour'd of them all;
And drunk delight of battle with my peers,
Far on the ringing plains of windy Troy.
I am a part of all that I have met;
Yet all experience is an arch wherethro'
Gleams that untravell'd world, whose margin fades
For ever and for ever when I move.
How dull it is to pause, to make an end,
To rust unburnish'd, not to shine in use!
As tho' to breathe were life. Life piled on life
Were all too little, and of one to me
Little remains: but every hour is saved
From that eternal silence, something more,

A bringer of new things; and vile it were
For some three suns to store and hoard myself,
And this gray spirit yearning in desire
To follow knowledge like a sinking star,
Beyond the utmost bound of human thought.
This is my son, mine own Telemachus,
To whom I leave the sceptre and the isle—
Well-loved of me, discerning to fulfil
This labour, by slow prudence to make mild
A rugged people, and thro' soft degrees
Subdue them to the useful and the good.
Most blameless is he, centred in the sphere
Of common duties, decent not to fail
In offices of tenderness, and pay
Meet adoration to my household gods,
When I am gone. He works his work, I mine.
There lies the port; the vessel puffs her sail:
There gloom the dark, broad seas. My mariners,
Souls that have toil'd, and wrought, and thought with me—
That ever with a frolic welcome took
The thunder and the sunshine, and opposed
Free hearts, free foreheads—you and I are old;
Old age hath yet his honour and his toil;
Death closes all: but something ere the end,
Some work of noble note, may yet be done,
Not unbecoming men that strove with Gods.
The lights begin to twinkle from the rocks:
The long day wanes: the slow moon climbs: the deep
Moans round with many voices. Come, my friends,
'Tis not too late to seek a newer world.
Push off, and sitting well in order smite
The sounding furrows; for my purpose holds
To sail beyond the sunset, and the baths
Of all the western stars, until I die.
It may be that the gulfs will wash us down:
It may be we shall touch the Happy Isles,
And see the great Achilles, whom we knew.
Tho' much is taken, much abides; and tho'
We are not now that strength which in old days
Moved earth and heaven; that which we are, we are;
One equal temper of heroic hearts,
Made weak by time and fate, but strong in will
To strive, to seek, to find, and not to yield.

CROSSING THE BAR.

Sunset and evening star,
And one clear call for me!
And may there be no moaning of the bar,
When I put out to sea,

But such a tide as moving seems asleep,
Too full for sound and foam,
When that which drew from out the boundless deep
Turns again home.

Twilight and evening bell,
And after that the dark!
And may there be no sadness of farewell,
When I embark;

For tho' from out our bourne of Time and Place
The flood may bear me far,
I hope to see my Pilot face to face
When I have crost the bar.

Mrs. E. B. Browning.—The most eminent English poet of her sex was Elizabeth Barrett, who, by marriage to Robert Browning, became known as Mrs. Browning (1809-1861). Her constitution was extremely delicate, her body very frail, her countenance expressive, her mind peculiarly sensitive. Her father, a country gentleman, encouraged her study of literature and the arts. Under a blind tutor named Boyd she became a proficient Grecian scholar and at an early age translated into English verse the *Prometheus* of Æschylus. A more original work was *The Drama of Exile,* suggested by Milton. Her weak health compelled a seclusion, relieved only by the companionship of books. Still more was this the case when her life was endangered by the bursting of a blood-vessel. To recruit her strength she had been taken to Torquay, and there was plunged in fresh anguish by the drowning of her favorite brother. Henceforth she seemed destined to an invalid's couch. During seven such years her only employment and enjoyment were reading and writing. Her lyrics show wonderful depth of feeling, and longer poems relate with power sad facts of human life. Deeply impressed with a report made by a government commission on the deplorable state of the factories, she appealed to her countrymen in *The Cry of the Children.* Suffering in any form enlisted her profound sympathy. Such intense feeling runs through her lament on *Cowper's Grave.*

In *Lady Geraldine's Courtship* Miss Barrett had made a pleasant incidental mention of Browning's *Bells and Pomegranates.* That poet, then without fame, called to thank her for her kind word, was permitted to visit the invalid, and encouraged her to hope for health. Their intimacy ripened into love, and Browning proposed marriage. Her father indignantly forbade him the house. Yet they met and were married in 1846, and when she could not stay at her father's house her husband carried her off to Italy. Love and change of climate wrought wonders. Casa Guidi, their home at Florence, became the resort of literary pilgrims. Mrs. Browning wrote much and profited by her husband's criticisms. Her pretended *Sonnets from the Portuguese,* written without his knowledge, told the idealized story of her own rescue from death by all-powerful love. Residence in Italy gave her that direct interest in the movement for Italian independence, which inspired *Casa Guidi Windows.* Her longest poem, *Aurora Leigh* (1856), has been called a novel in blank verse. It professes to be an autobiography but does not relate her own experience. Its central figure is a cultivated woman of the nineteenth century brought to face new moral and social problems by the very fact of her culture. For a while Mrs. Browning's admirers considered this the firm foundation of her fame, but as time has passed it has fallen into neglect as a work of but temporary value. Such changes have taken place in the whole sphere of education and in the condition of women that the subject has lost the novelty which made it immediately attractive. Yet there are undeniable passages of lofty poetry, though too many of mediocrity. The author's aim was to teach that true art leads the soul to contemplate God as the supreme artist. After fifteen years of happy married life Mrs. Browning died at Florence. She had lived to see Florence made, by the statesmanship of Cavour, the capital of the new kingdom of Italy. Casa Guidi is marked by a memorial tablet set up by the grateful city. Long after her death the world has, by favor of her son, been permitted to enjoy *The Letters of Robert Browning and Miss Barrett, 1845-46* (1902). Though she was once thought decidedly superior to her husband in poetry, that estimation has been, in many respects, reversed. Yet she holds an assured place among the great poets of England. She had a passionate sense of beauty, and the pathos of some of her poems is thrilling.

Robert Browning (1812-1889). — Although Browning began in early youth to write poetry and published at the age of twenty, he was late in attaining general recognition. But when that recognition came, it came with a rush. His poetry became a subject of party strife; it led to the formation of societies for its study and interpretation. The study became a cult. Browning lived long enough to enjoy this curious popularity, but he was not moved by it from his predetermined course. He mingled in society on equal terms with others, appearing only as a private gentleman.

He was born in a suburb of London, and was taught privately, being excluded from the universities because he was a Dissenter. Yet his scholarship was sound and thorough. In his boyish poetic attempts he first followed Byron, then Shelley and Keats. After much ambitious planning, which resulted in little accomplishment, he published anonymously *Pauline* (1833), which is a morbid confession of sin. It received scant attention except from D. G. Rossetti and J. S. Mill.

Browning went abroad and spent a long time in Italy, studying its literature. On his return he published *Paracelsus* (1835), an attempt to explain the character of that strange mixture of scientist and charlatan. Browning always had a fondness for the theatre and prepared the tragedy of *Strafford* for the stage in 1837. Macready, who enacted the title role, had assisted in the work. Its success was enough to induce the author to present, later, *A Blot in the Scutcheon* (1843) and *Colombe's Birthday* (1852). They had good characters and eloquent speeches, but there was perhaps a deficiency of action. Other dramatic poems were never put to the test of the stage; *Pippa Passes* (1841), however, has always been a favorite with Browning's admirers; *King Victor and King Charles* (1842) and *The Return of the Druses* (1843) are powerful as poems and have high dramatic qualities. But the poem *Sordello* (1840), treating of an obscure troubadour, was generally condemned as too difficult to understand. It would require, first, a mastery of the history of Italy in the Middle Ages. An outcry was raised against Browning for his intentional obscurity. Yet his next publication, *Dramatic Lyrics* (1842), contained many pieces which at once captivated the public and have since remained favorites for school recitations, *How They Brought the Good News from Ghent to Aix, An Incident of the French Camp.* Even more popular was the legend of *The Pied Piper of Hamelin.* Browning now made a collection of his poems in *Bells and Pomegranates* (1846), a title drawn from the ornamental fringe of the Jewish priests.

Elizabeth Barrett, then more favorably known, made a happy allusion to this collection in one of her poems, and Mr. Browning waited upon the secluded invalid to thank her for the notice. The interview led to further intimacy, love and courtship. When her father, through mistaken affection, persisted in confining her to the house, she was persuaded to marry without his consent. The two poets left England and found a congenial home in Florence, Italy. The wife gained health and strength, and published much. The husband did apparently little. Their home, Casa Guidi, became a Mecca for literary pilgrims, who united in testifying to their charming hospitality and entertaining conversation. Browning's poems of this period were gathered in *Christmas Eve and Easter Day* (1850) and *Men and Women* (1855).

In 1861 Mrs. Browning died and her husband returned to London, making it his residence for the rest of his life, yet frequently visiting Italy. In 1869 he astonished the world, which had begun to recognize his merit as a poet, with his portentously long and curiously involved story in blank verse, *The Ring and the Book.* The strange incident which forms the foundation of the poem is told and retold many times. The object is to show how persons of different character view what they witness and take part in, and to exhibit the operation of their minds. In two poems Browning introduced free but masterly translations from Euripides: in *Balaustion's Adventure* he used the *Alkestis,* and in *Aristophanes' Apology* the *Herakles.* Later he rendered, in a more exact way, the *Agamemnon* of Æschylus. Such works, of course, appeal only to classical scholars, and, in fact, most of Browning's poems demand specially trained intelligence in his readers. This fact is the reason and justification of the forming of the societies to study his works. Year after year he sent forth new volumes, attesting his wide range of knowledge and his interest in all manifestations of the human soul. He delighted to explore men's motives, to show how much good may still remain in men of evil lives. *Prince Hohenstiel-Schwangau* (1871) is considered to be a study of Napoleon III, just as *Mr. Sludge the Medium* was of the spiritualist Hume who mystified the citizens of London and St. Petersburg. In several of his poems forgotten celebrities were called back from oblivion. When they came he was not content to show the external figure, but must reveal the hidden springs of their actions. Such poetry is not intended merely to give pleasure; it is to arouse the soul, to train it to see worlds not heretofore realized, to exert its own unimagined potencies. Browning died at Venice, during a summer visit. He was buried in Westminster Abbey with manifestation of the English people's grief.

Browning had continued to write till the very end of his long life, and his wonderful intellectual and imaginative power seemed in no way abated. His fame appears still to increase, as readers have become assured that the effort of study will be abundantly repaid by enlargement of the powers of the soul. Browning's faults are on the surface —his abrupt, spasmodic style which often seems to come from a conflict between two or more modes of thought or expression. Yet when he chooses, none can be more musical or clearer than Browning. He is also a most suggestive poet. With a word or two he can touch the heart or enlighten the intellect. Impressive pictures start from his verse as if by a musician's wand. Again he draws illustrations from afar, making the whole world, past and present, tributary to his genius. His wide sympathy and keen insight made him a cosmopolitan, while his interest in each individual enabled him to reproduce race, epoch, caste, sect and eccentricity with unfailing fidelity. Yet he did not exhibit full dramatic power; he used, rather, the dramatic monologue, which omits the necessary action. To be fully understood and enjoyed he must be read not in snatches, but in all his fulness and waywardness. He will be found to possess a masculine optimism, not to be daunted with spectres and portents of evil.

THE LOST LEADER.

Just for a handful of silver he left us,
Just for a riband to stick in his coat—
Found the one gift of which fortune bereft us,
Lost all the others she lets us devote;
They, with the gold to give, doled him out silver,
So much was theirs who so little allowed:
How all our copper had gone for his service!
Rags—were they purple, his heart had been proud!
We that had loved him so, followed him, honoured him,
Lived in his mild and magnificent eye,
Learned his great language, caught his clear accents,
Made him our pattern to live and to die!
Shakespeare was of us, Milton was for us,
Burns, Shelley, were with us—they watch from their graves!
He alone breaks from the van and the freemen,
—He alone sinks to the rear and the slaves!
We shall march prospering—not thro' his presence;
Songs may inspirit us—not from his lyre;
Deeds will be done—while he boasts his quiescence,
Still bidding crouch whom the rest bade aspire.
Blot out his name, then, record one lost soul more,
One task more declined, one more footpath untrod,
One more devil's-triumph and sorrow for angels,
One wrong more to man, one more insult to God!
Life's night begins: let him never come back to us!
There will be doubt, hesitation and pain,
Forced praise on our part—the glimmer of twilight,
Never glad confident morning again!
Best fight on well, for we taught him—strike gallantly,
Menace our heart ere we master his own;
Then let him receive the new knowledge and wait us,
Pardoned in heaven, the first by the throne!

EPILOGUE TO ASOLANDO.

(Browning's last writing.)

At the midnight in the silence of the sleep-time,
When you set your fancies free,
Will they pass to where—by death, fools think, imprisoned—
Low he lies who once so loved you, whom you loved so,
—Pity me?
Oh to love so, be so loved, yet so mistaken!
What had I on earth to do
With the slothful, with the mawkish, the unmanly?
Like the aimless, helpless, hopeless did I drivel
—Being—who?
One who never turned his back, but marched breast forward,
Never doubted clouds would break,
Never dreamed, though right were worsted, wrong would triumph,
Held we fall to rise, are baffled to fight better,
Sleep to wake.
No, at noonday in the bustle of man's work-time
Greet the unseen with a cheer!
Bid him forward, breast and back as either should be,
"Strive and thrive!" cry "Speed—fight on, fare ever
There as here!"

Swinburne.—Among the chief singers of the Victorian choir, Algernon Charles Swinburne early won a prominent place. He was born in 1837 near Henley on the Thames, his father being an admiral and his mother a daughter of the Earl of Ashburnham. He was well educated, partly in France and partly at Oxford, but did not graduate. After a sojourn in Italy he settled in London and published some dramas, among which *Atlanta in Calydon* (1864) especially attracted attention as a successful imitation of Greek tragedy. *Chastelard* (1865) is founded on the story of a page of Mary Queen of Scots. In 1866 he published *Poems and Ballads,* which first exhibited his wonderful mastery of the English language, enabling him to draw from it most exquisite music. But some of the poems shocked readers by their sensuality and roused loud protests. His later poems were equally musical and more free from reproach on moral grounds. Although of aristocratic birth, Swinburne is a radical democrat and showed much interest in the republican movements in France and Italy. His *Songs Before Sunrise* were dedicated to Mazzini. In the *Songs of Two Nations* the "Song of Italy" is conspicuous. His dramatic tendency appears in *Tristram of Lyonesse,* a rhymed narrative. From Sir Thomas Malory he drew *The Tale of Balen,* which was later also used by Tennyson in one of his idylls. Swinburne returned to the story of Mary Queen of Scots in his dramas *Bothwell* and *Mary Stuart.* In all of them he condemns the unfortunate queen as a wanton. Besides his poetical and dramatic work, Swinburne has written critical, biographical and controversial essays. He has discussed the Elizabethan dramatists and later English poets, showing keen insight and often extravagant admiration. But his fame rests on his surprising development of the musical capacity of the English language.

Sir Edwin Arnold.—*The Light of Asia,* a poetical exposition of the principles of Buddhism and the story of its founder, gave Edwin Arnold (1832-1904) sudden but hardly lasting fame. He was born in Sussex, England, and after graduating at Oxford engaged in teaching. As principal of a Sanskrit college at Poonah, India, from 1857 to 1861, he acquired that special familiarity with the religions of Asia which is displayed in his later work. Returning to England for a vacation, chance led him to an editorial position on the London *Telegraph.* His first poetical work consisted in translations from Greek and Sanskrit. In 1879 he issued his paraphrase of the life and teachings of Buddha. English readers were captivated by its brilliant local color, its gorgeous imagery and its striking resemblance to the Christian Gospels. But Arnold's purpose was not yet accomplished. He wished to make known other great religious systems. *Indian Idylls* (1881), taken from the Hindu epic, *Mahabharata,* revealed the Brahmin faith; *Pearls of the Faith, or Islam's Rosary* (1883), was an exposition of Mohammedanism; *Sadi in the Garden, or the Book of Love* (1888), is a translation from the great Persian poet, Sadi. Finally, the story of Jesus was told in a similar way in *The Light of the World* (1892).

None of these later works attained the success of that on Buddha. They seemed even to diminish its effect. Arnold's visit to Japan in 1892 furnished material for his prose work, *Japonica,* and led to his marriage with a Japanese lady. His former wife was an American. Arnold was a versatile journalist, and gratified the public with descriptions of strange lands and peoples. His friendly exposition of Asiatic religions brought him high honors from the King of Siam, the Sultan of Turkey, the Shah of Persia and the Emperor of Japan. Queen Victoria also, in 1888, created him Knight Commander of the Indian Empire. Arnold's works have done much to enlighten the adherents of various religions, and better acquaint them with each other's views. His poetry is picturesque and the metre pleasant, but the embellishment too lavish to suit the Western mind.

Fitzgerald.—In 1859 was published a remarkable English translation of a Persian astronomer-poet of the twelfth century. Copies lay neglected at the bookseller's till the price was reduced to a penny. Then its merit was accidentally discovered, and gradually its fame arose, for the musings of the forgotten Persian were found to be adequate expression of the thoughts of thousands of English-speaking people. The Persian poet was Omar Khayyam, who had reformed the Mohammedan calendar, and his poems were called *Rubaiyat* or *Quatrains.* The translator was Edward Fitzgerald (1809-1883), an eccentric friend of Tennyson. He was born near Woodbridge, in Suffolk, but was of Irish descent, being the son of John Purcell, who took the name Fitzgerald in 1818 on the death of his wife's father. He graduated at Cambridge University, and spent his life at or near his native place. Though a wealthy gentleman and scholar, he disliked the conventions of society, and amused himself with boating and yachting. His bachelor home was in a cottage at the park gates of Boulge Hall, where his family resided. His usual companions were the boatmen of the village, yet with scholarly friends he held pleasant intercourse. He became intimate with the Quaker poet, Bernard Barton, and, after Barton's death, married his daughter Lucy. But their habits were so dissimilar that they soon parted.

Fitzgerald's first publication was *The Life and Letters of Bernard Barton.* In 1851 he issued *Euphranor,* a quaint dialogue on youth. Prof. E. B. Cowell, of Oxford, induced him to take up the study of Spanish, which resulted in his publishing *Six Dramas of Calderon* (1853). The translation was intentionally free, but the reviewers criticised it so severely that he withheld from the press other dramas which he had prepared. Cowell called his attention to Persian poetry and assisted him in his study of it. The translation of Omar Khayyam was made in the peculiar metre of the original. When the quatrains began to attract notice, Fitzgerald went over his work again, revising, enlarging and adding freely similar thoughts in the same metre. Four versions were thus prepared, the first and the last being considered the best. From Persian the scholarly recluse passed on to Greek, and prepared with his customary freedom translations of the *Agamemnon* of Æschylus, and of the *Œdipus Tyrannus* of Sophocles. But the comments of captious critics on the former again caused him to withhold the latter. Tennyson had dedicated to his old friend his *Tiresias,* but Fitzgerald died on the eve of its publication, and Tennyson added a pathetic epilogue.

The *Rubaiyat* of Omar Khayyam has been interpreted by European as well as Mohammedan editors as having a mystic significance, in which, for instance, wine represents faith. But Fitzgerald rejected all such sophistry and took the whole poem in its plain sense, as a forcible expression of pessimism. The philosopher who has studied the various creeds and systems of his predecessors finds them all unsatisfactory in solving the riddle of life. He therefore falls back on present enjoyment as a sufficient practical guide. To such a solution many thoughtful minds of the century were tending when Fitzgerald's poem appeared, and it was accepted as a beautiful and, even though sensual, not immoral conclusion of the matter.

George Eliot (1819-1880).—Under this masculine pen-name a woman won remarkable fame as a novelist. She was born Mary Ann Evans, at Nuneaton, in Warwickshire, where her father was a land-agent and surveyor. The youngest of five children, she was educated far beyond what was usual with girls. Her early life was among strictly religious people, but after her mother's death, having removed with her father to the neighborhood of Coventry, she came into close association with the Brays, a family of intellectual free-thinkers. Through their influence she gave up the Calvinistic theology which she had been taught, and eventually all distinctive Christianity, yet retaining her high respect for all sincere religious belief. Her first publication was a translation of Strauss' *Life of Jesus* (1846), which had been begun by one of her new friends. In 1849 the death of her father, to whom she had been warmly attached, overwhelmed her with grief. But the Brays took her to the Continent and she resided at Geneva for eight months. Her local attachments being broken, she was induced to go to London to assist in editing the *Westminster Review.* For it she wrote critical, literary and ethical essays.

Close association with men eminent for intellectual attainments gave her new life. Among them was George Henry Lewes (1817-1879), who held the Positivist philosophy of August Comte. Lewes was separated from his wife, who had twice been guilty of adultery, but from whom he could not, by English law, receive a divorce because he had pardoned the first offence and received her back. Lewes was of decided literary and scientific tastes and had published some novels, as well as a *Biographical History of Philosophy.* Miss Evans was attracted by sympathy in his views and charmed by his brilliant conversation. Induced by a recognition of mutual helpfulness, she entered into a life-union with him and assumed his name, although without legal or social sanction. Many of her friends were alienated, but her literary associates approved her course. To Lewes she was a most faithful wife and to his children a most devoted mother. For some time they lived in Germany, but when they returned to London their house became a favorite literary resort.

Lewes discovered his wife's genius and found its proper mode of expression when he suggested to her the writing of fiction, and encouraged her in it. The first attempts were *Scenes of Clerical Life,* published in *Blackwood's Magazine* in 1857 under the pseudonym George Eliot. This name was retained when she published *Adam Bede* (1859), but the success of that work was so great that she disclosed the secret. The pseudonym, however, was retained and is still generally used to designate the author. Her stories were about commonplace English people, whose characters, struggles and temptations she made so vivid and real as to excite universal sympathy. Heretofore it had only been exceptional cases of that class that were thought worthy of artistic treatment, producing melodramatic naturalism. George Eliot adhered strictly to real life, but she showed its spiritual significance.

Her intimate knowledge of a class of English people heretofore unrepresented in literature, the sober, quiet, religious middle class, remote from the excitements of city, rather narrow-minded, yet with human passions and desires, and her imaginative power, enabled her to excite interest in these novel phases of character. The strictly religious Adam Bede, the carpenter, was in some respects drawn from her own father, and Dinah Morris, the Quaker preacher, from an aunt. In the tragic story of *The Mill on the Floss* (1860) she treated more complex moral problems, arising from different dispositions in members of the same family. Upright Tom Tulliver misjudges his sister Maggie's affectionate and imaginative nature and treats her cruelly. *Silas Marner* (1861) is a story of the Methodist revival, in which a poor, misanthropic, miserly weaver is consoled for the loss of his gold by finding a little girl at his fireside.

So far George Eliot had drawn only from her own actual experience of life, though treating it with new imaginative power as well as loving sympathy. Her confirmed success led her to enter the grander field of historic fiction. In *Romola* (1863) she essayed the difficult task of restoring the life of Florence in the fifteenth century, the age of Lorenzo the Magnificent and the martyrdom of the preaching friar, Savonarola. The interest of the story turns on other characters—the treacherous Tito Melema and the aspiring, unhappy Romola. In *Felix Holt, the Radical* (1866), George Eliot returned to English ground, but was less successful in depicting political movement than she had been in religious. *Middlemarch* (1872) is perhaps the greatest of her novels in dealing with modern characters. The beautiful, noble, serious Dorothea is married to the artistic, trifling Ladislaw; Lydgate, with his great reformatory ideas, is ensnared by selfish Rosamond; the learned Casaubon wastes his life in dreams about his great work never to be done. Other life-failures are shown which enforce the importance of morality to success. *Daniel Deronda* (1876), the last of her novels, exhibits a faultless hero, who feels himself the bearer of a great mission, yet does not arouse enthusiasm. There is more attraction in the development of the heroine, Gwendolen. The public neglected its pictures of modern Jews and their hopes. George Eliot's last publication was *The Impressions of Theophrastus Such* (1878), a collection of aphorisms or moral reflections. Besides these prose works, she had composed some poems, *The Spanish Gypsy* (1868), *Agatha* (1869), and *Jubal* (1876). But these, though approved by many critics as admirable, never attracted general attention. Mr. Lewes died in 1878. In 1880 his widow was married to John W. Cross, but she died before the end of that year. Mr. Cross published her biography in 1884.

The early criticisms which George Eliot contributed to the *Westminster Review* have a double interest, as they show that she had formed a distinct opinion about the novelist's art before she ever ventured into that field. She suggested that the full revelation of the heart, mind and feelings of the humble characters in Dickens' stories would be a valuable contribution to art, tending to awaken social sympathies. Something like this was the task which she afterward set for herself, and nobly did she accomplish it, not merely for the lowly and despised, but for the talented and admired. It was done with boundless sympathy and unfailing humor. She was a realist, not merely depicting odd figures and reporting their speech, but revealing their motives and laying bare their hearts.

Trollope.—Anthony Trollope (1815-1882) was perhaps the most prolific novelist of his time, yet he was late in beginning to write. His first book, *The Warden* (1855), in which the chief character is a simple-minded, conscientious clergyman, was the beginning of a series comprising *Barchester Towers, Doctor Thorne, Framley Parsonage, The Small House at Allington* and *The Last Chronicle of Barset*. In these, certain characters and whole families appear again and again, so that the reader keeps watching for old acquaintances or their relatives. They all belong to England of his day, and range from the lower middle to the upper class, including especially clergymen and their wives. The stories contain the ordinary incidents of life, and the conversation is sprightly. In *Phineas Finn* and some other books Trollope entered the region of politics, giving sketches of Gladstone and Disraeli under other names. He wrote a few books of a different class, but not successfully. He had an official connection with the Post Office, which, however, did not occupy much of his time. The public were surprised to learn from his *Autobiography* that he did his writing almost mechanically, so many words an hour, and were disposed to underrate the value of what they had previously prized.

Reade.—Charles Reade (1814-1884) was born at Speden, near Oxford, graduated at that University and was elected a Fellow of Magdalen College. This gave him independence, so that he was slow in beginning to write. After some unsuccessful attempts at drama he published, in 1852, *Peg Woffington,* a brilliant short story. His *Griffith Gaunt* is a powerful but disagreeable picture of life in the eighteenth century. *It Is Never Too Late to Mend* (1856) is a tale of his own times, exposing the ill treatment of prisoners and describing mining life in Australia. *The Cloister and the Hearth* (1861), his longest and greatest work, professes to relate the story of the father of Erasmus in the fifteenth century. Though he borrowed some from Erasmus himself, he added romance, passion and pathos. He used to accumulate newspaper clippings of strange facts and incidents, which he arranged and indexed in huge scrap-books, and then drew from these sources such details as he required for his powerful stories of modern life. Yet it was rather his own genius than this patchwork that enabled him to reveal the gloom of prisons, the horrors of mad-houses, the outrages of trade-unions and the perils of the sea. His stories show him a man of strong likes and dislikes. He assisted in dramatizing some of his stories, and had lawsuits and newspaper controversies about the copyrights.

Collins. — Wilkie Collins (1824-1889) was a prominent member of Dickens' staff in the *Household Words,* and was noted for his skill in constructing intricate plots. The reader of the serial was kept in anxious suspense from week to week until the elaborate tangle should be unraveled. This sensation was especially produced by the *Woman in White* (1860), in which was presented his most life-like character, the plausible, fat Italian, Fosco, adventurer and villain.

Hughes.—The most successful attempt at portraying school-boy life is *Tom Brown's School Days* (1856), by Thomas Hughes (1823-1896), who afterward became a member of Parliament. The title-page of his book correctly describes him as "an Old Boy." Throughout his life, devoted to earnest endeavors to benefit workingmen and others, he retained much boyishness of spirit and interest in boys' affairs. He was really Tom Brown himself, while his friend, little Arthur, was afterward Dean Stanley. The book was a tribute to Dr. Arnold and his system of education at Rugby. It was followed by *Tom Brown at Oxford* (1861), written with studious accuracy, but not the native force of the Rugby book. His other books were popular discourses on practical religion.

Freeman.—The Victorian era was distinguished by a number of able historians of widely different types. With a consuming passion for truth and accuracy even in the minutest particulars, Edward Augustus Freeman (1823-1892) wrote diligently not only the great histories which bring him solid fame, but monographs and articles for reviews, magazines and newspapers on various subjects. Through them all one spirit is easily traced. "History," said he, "is past politics; politics is present history." These two subjects, which he pronounced one and the same, dominate nearly all his writings. He was born at Harbourne, in Staffordshire, and was educated at Trinity College, Oxford. His earliest writing was on architecture, treating of church restoration and the cathedrals of England. But he soon turned to more important work in his *History of the Saracens.* The *History of Federal Government* was suspended when only one volume was completed. He spent much time and labor in ascertaining facts in early English history and in controverting the incorrect statements of others. His greatest work is the *History of the Norman Conquest* (6 vols., 1867-1876), written in a graphic style and abounding in evidence of careful research. But his attention was confined to public men and leading events, to William and Harold and the battles between them; he did not investigate the actual condition of the people, Saxon and Norman. The characters are carefully portrayed and the story is told with animation. He insisted on spelling Anglo-Saxon names in the original form, making Alfred into Aelfred, etc. To accommodate readers whose time is limited, a *Short History of the Norman Conquest* (1880) was afterward prepared. The larger history was extended in the *Reign of William Rufus* (1882). From his constant stream of articles in reviews three series of *Historical Essays* were collected. Several of his works treated of the Turks and their government, to which he was bitterly opposed. Others related to the growth of the British constitution and to various forms of government. In 1881 Freeman visited America, lecturing in the principal cities; these sprightly lectures on the development of the English race gave a better impression of the man himself. His *Impressions of the United States* (1883) also showed him to be a kindly observer rather than a carping critic. His latest work was a *History of Sicily* (3 vols., 1883-1892), which was left incomplete. Freeman, ever fond of travel, died in Spain.

Froude.—The most brilliant historian of the latter nineteenth century was James Anthony Froude (1818-1894). In character and career he affords many contrasts with Freeman, who seemed to delight in pointing out Froude's mistakes, yet could not seriously diminish the regard felt for his history. Froude was the son of a clergyman, and was educated at Westminster and Oxford, where, under the influence of Newman, he was drawn into the Tractarian movement, and assisted in writing *Lives of the English Saints.* But when Newman entered the Roman Church Froude recoiled, and, falling into skepticism, wrote *The Nemesis of Faith* (1849). Carlyle now became his adviser. From conscientious motives Froude gave up his college fellowship and sought to make a living by literary work, writing for *Fraser's Magazine* and the *Westminster Review* the essays that were afterward collected in *Short Studies.* But his chief work is the *History of England from the Fall of Wolsey to the Defeat of the Spanish Armada* (12 vols., 1856-1870). It was founded on original research, on a careful examination of the documents of the period, especially the act of Parliament. Froude, with his animated style and thoroughly English spirit, restored life to the past and rendered the personages introduced real. Bluff Henry VIII, stately Queen Catharine, unfortunate Mary Queen of Scots, bigoted Mary of England and domineering Elizabeth seemed again actual human persons, though whether they preserved exact resemblance to the originals was keenly disputed. Froude's intense patriotic feeling made him resist the mediæval tendency which had been at work in history as elsewhere. He sought to prove that in the main England had acted right in the momentous crisis of the Reformation. Another subject fruitful in controversy was next handled in *The English in Ireland* (3 vols., 1871-1874). This partisan work supported the general course of the alien rulers. Froude was sent by the British Government to visit and report on the colonies. The literary result is seen in his *Oceana,* a general sketch, and *The English in the West Indies.* Froude was appointed by Carlyle his literary executor, and as such gave to the world the grumbling and growling of the *Reminiscences,* which the writer had marked not to be published without revision. The result was to exhibit the philosopher as a chronic faultfinder, snarling at everybody. His admirers were intensely displeased and threw the blame on Froude for indiscretion in editing the papers. But the bold writer went steadily on his course. Froude, though much disliked by the leading critics, was appointed to succeed Freeman as professor of history at Oxford. His three courses of lectures were published in *The Life and Letters of Erasmus, English Seamen of the Sixteenth Century* and *Lectures on the Council of Trent.* They give further example of the qualities seen in his previous historical works—lively picturesque style, skill in rendering characters and incidents as real, and occasional carelessness in details. In his effort to preserve the spirit of the past he treated his subjects artistically.

Lecky.—A philosophic historian who discussed social movements rather than events, ideas rather than individuals, was William Edward Hartpole Lecky (1838-1904). Born at Dublin, he graduated from Trinity College of that city in 1859. His first work, published anonymously, was *Leaders of Public Opinion in Ireland* (1861), treating of Dean Swift, Flood, Grattan and O'Connell. Its flowing style and wide sympathy won general favor. After extensive travel on the Continent, Lecky settled in London and published his *History of the Rise and Influence of the Spirit of Rationalism in Europe* (1865). Rationalism was defined to be that cast of thought which leads men to subordinate dogmatic theology to the dictates of reason. The peculiar nature of this philosophic work, treating of magic, witchcraft, miracles, persecution and the separation of politics from the church, drew to it special attention. The *History of European Morals from Augustus to Charlemagne* (1869) is a parallel work. Lecky rejects utilitarian ideas and considers morality as intuitive. He contrasts the Stoic and Epicurean systems with Christian morality, and finds a main cause of the conversion of the Roman Empire in the adequacy of the latter to the wants of the age. The rise of asceticism and monasticism is traced to evils for which they were temporary remedies.

Lecky's voluminous *History of England in the Eighteenth Century* (1878-1888) is a collection of essays on the prominent facts and features of the nation's life. It discusses separately the nature of monarchy and aristocracy, the growth of democracy, the increasing power of Parliament and the press, religious liberty, the rise of Methodism and the origin of the French Revolution. Considerable space is given to Irish affairs, and later this part was printed separately as a *History of Ireland.* It relates chiefly to the rebellion of 1798 and is markedly impartial. The part relating to the American Revolution has also been issued separately in this country. Lecky was elected to Parliament, but attained no prominence there. His reputation as a philosophic historian has grown steadily.

Kinglake.—The prodigious scale on which modern history is often constructed is exemplified in Kinglake's *History of the Crimean War,* which occupies seven volumes, though the war lasted but two years. Alexander William Kinglake (1811-1890) was educated at Eton and Cambridge. His travels in the Levant furnished material for *Eothen* (1844), a gem of literary art. His adventures were related in a lively, humorous style, smart and sometimes flippant. Kinglake was elected to Parliament, but was never a prominent member. From love of adventure he visited the Crimea during the war and received kindness from Lord Raglan, which he abundantly repaid. At the request of Raglan's family he undertook the history, and then made most careful study of all the details of the war. Accounts of these he arranged in the most orderly fashion, so that an affair of ten minutes may be spread over seventy pages. A volume is given to the battle of Inkermann. His partiality toward Lord Raglan and other British generals is offset by his prejudice against Napoleon III and the French commanders. His admiration for the Russian defender of Sebastopol, Todleben, is unbounded. His style is too brilliant for history. The entire work was condemned by Matthew Arnold as a striking example of British bad taste, seeking the grand in the prodigious.

Green.—The most popular historian of the age was John Richard Green (1837-1883). Born at Oxford, he was educated there without obtaining distinction. He entered the Church, and in 1865 became vicar of Stepney in East London. Holding High Church views, he was active in parochial duty and in charity organization. To eke out his slender income he wrote for the *Saturday Review* articles on historical and social topics, which were afterward collected as *Stray Studies in England and Italy.* Part of them were derived from his winter visits to Italy on account of his delicate lungs. When his health was broken down by parish work and his former rigid Church views abandoned, he retired from active clerical work. Archbishop Tait made him librarian at Lambeth, where Green wrote his *Short History of the English People* (1874). It was at once received with enthusiasm. His aim was to entertain as well as instruct, to exhibit the life of the people in successive stages rather than recount the doings of kings and courts. His vivid, picturesque style brought distant times and places close to view. The work was soon enlarged to four volumes, still retaining the methods and style which had given the original popularity. Then he sought to go more deeply into the origin of England's greatness, and in *The Making of England* (1882) treated the early Anglo-Saxon period. This was to be followed by *The Conquest of England,* but the work was interrupted by his death at Mentone, Italy. His wife had faithfully watched over his precarious health and helped him as amanuensis. Since his death she has superintended special editions of his works. The distinguishing merits of Green's work are his wide human sympathy and his power to make the past real to the imagination.

Gardiner.—Samuel Rawson Gardiner, born in 1829, was professor of modern history in King's College, London. He devoted himself especially to the history of the seventeenth century. He published the *History of England from the Accession of James I to the Restoration,* a remarkably impartial presentation of an age full of party conflicts. While he won the esteem of special students, he did not attain the popularity of his great predecessors. Apart from this, he published an excellent *Student's History of England* and several books describing epochs and characters of the period of his chief work.

McCarthy. — Justin McCarthy, born at Cork, Ireland, in 1830, has been an active politician and journalist, and has written some novels of merit. His chief historical work is *A History of Our Own Time* (1879-1902), notable for its fairness in treating political questions still in dispute. The success of this work led him to write a *History of the Four Georges* (1889) and a *History of Ireland,* which show the same excellent qualities.

Ruskin.—Perhaps the greatest master of English prose is John Ruskin (1819-1900), who, after setting out to be an artist became an art critic, and thence proceeded to be a critic of everything pertaining to human life. Born in London, the only son of a wealthy wine merchant, he received a strict religious training from his Scotch mother. After finishing his education at Oxford he journeyed on the Continent and studied art. In 1843 appeared the first volume of his *Modern Painters. By an Oxford Graduate.* To art-neglecting, dim-eyed England, immersed in business and politics, it was a dazzling revelation of a new world. Æsthetics had not been cultivated; few paintings were publicly exhibited, private collections were small and limited. The new prophet of art, deeply imbued with the Romantic revival, and devoted to Sir Walter Scott, found in the splendid nature-painting of J. W. M. Turner a noble realization of his own ideas, and became the herald of his genius. But he had to teach an ignorant, hostile crowd, who were prejudiced against him when he assailed names hallowed by tradition. A second volume was issued in 1846, and the fifth in 1860, the original plan having been remodeled. Ruskin's *Seven Lamps of Architecture* (1849) applied to another department the principles on which he insisted that true art involves the highest morality.

The very names of the seven lamps are sufficient to show his strangely spiritual way of treating the subject. They are sacrifice, truth, power, beauty, life, memory, obedience. His next work, the *Stones of Venice* (1853), treated sculpture in the same grand way, bringing ethics into essential relation with æsthetics. Ruskin's views of art, presented with splendid rhetorical force, made constant headway. For a while he had been derided, but his influence as an art teacher rose. To him was due the Pre-Raphaelite movement, though those concerned in it were not his followers. It flourished about 1850, but afterward dissolved. Ruskin was made a professor of fine arts at Oxford in 1870, and gave £5,000 to endow a master of drawing.

A new stage in Ruskin's career was inaugurated with his *Political Economy of Art* (1858), or rather with *Unto His Last* (1862). In opposition to common views of political economy, he taught that there is in beauty the highest utility. Henceforth his mission was to teach new views of social duty. *Sesame and Lilies* (1865) treats of female education; *The Crown of Wild Olive* (1866) treats of civic duty; *The Queen of the Air* (1869) discusses the Greek myths of cloud and storm. Ruskin sometimes advocated socialism and advanced impracticable projects for the benefit of workingmen. He tried bravely to put his schemes into practice and eventually spent his large fortune in coöperative works of various kinds. His dogmatism on all subjects provoked revolt, yet his books were eagerly read. For fourteen years he published, at irregular intervals, rambling papers called *Fors Clavigera,* addressed to workingmen and intended to further his benevolent factories and communities. His most amazing self-sacrifice was his relinquishing his wife to the painter Millais when he found that they had fallen in love with each other.

Toward the close of his career Ruskin published a frank, fascinating autobiography, *Præterita,* not without many digressions into all manner of subjects. Some of his essays were collected in *Arrows of the Chace.* His later writings are often colloquial, yet sometimes rising into passages of grand eloquence. Ruskin was master of a grand ornate style, sometimes unduly florid, tending to become blank verse in prose. This tendency was held somewhat in check by regard for the beauties of nature and art which he aimed to describe. In ideas he was an unsafe guide, full of visionary notions. And yet, indirectly and in unexpected ways, his teaching has had much positive effect on English-speaking people, not only by awakening them to the beauty of nature and the value of art, but by quickening their moral sense in the conduct of life.

Matthew Arnold.—The most eminent critic and unfolder of the true principles of criticism was Matthew Arnold (1822-1888). He was the eldest son of Dr. Thomas Arnold, the renowned head master of Rugby. He was educated at Oxford and became one of the best representatives of its culture. For most of his life he was a government inspector of schools, and his reports had considerable effect in enlarging the scope and improving the methods of middle-class instruction. But his vocation was as a poet and critic. His first book of poems, *The Strayed Reveller* (1849) appeared anonymously; his second, *Empedocles on Etna* (1853) was recalled after a few copies were sold. But a collection from these was issued with a preface discussing poetry. In his view the true worth of poetry depends on the subject and its appropriate treatment, not on occasional bursts of beautiful thought. Arnold was professor of poetry at Oxford for ten years from 1857. Though strongly influenced by Wordsworth, his high culture disposed him to go back to Greek literature for form and models. His tragedy *Merope,* in the Greek style, was a failure.. He was the poet of thought rather than life. Among his long poems the most notable are *Sohrab and Rustum,* a tragic narrative from Persia; *The Sick King in Bokhara; The Scholar-Gypsy,* which describes finely the country around Oxford, and *Thyrsis,* a noble elegy on his friend A. H. Clough. Many of his short poems are full of romantic grace, but in the longer elaborate poems the style is too stiff.

His *Essays in Criticism* (1865) satirized English lack of culture and pointed out what the French Academy had done for common writing. The ordinary Englishman, absorbed in material things, indifferent to art and intellectual pleasure, was held up to scorn as a Philistine—an enemy of light. Criticism was declared to be "a disinterested endeavor to learn and propagate the best that is known and thought in the world."

Arnold next entered the theological field, for which he was less qualified by knowledge and training. Yet his *Literature and Dogma, God and the Bible, St. Paul and Protestantism* were none the less widely read. With keen wit and a lordly air he attacked the crude notions and palpable inconsistencies of common beliefs. He insisted that the language of the Bible is not fixed and scientific, but fluid and literary. But the new definitions he proposed deserve little favor. God he defined as "the Eternal not-ourselves which makes for righteousness;" salvation is "a harmonious perfection only to be won by cultivating many sides in us." His earnest desire was for "sweetness and light."

After a while Arnold returned to purely literary work, varying it with political discussion. For books of selections from Byron, Shelley and Wordsworth he wrote introductions of varying value. He made two visits to the United States, lecturing in the principal cities on literary topics. His *Discourses in America* contained several utterances hardly acceptable to his hearers. His death happened suddenly after his return to England.

This avowed apostle of culture had a deep and abiding influence on English thought and writing. His ideals were high, but his polished productions are critical and stimulating rather than creative. They excite admiration by the keenness of their insight and clearness of their analysis. He waged constant warfare against materialism and cant and drove them from the open field of public discussion.

Symonds.—Eminent as a critic of art and literature was John Addington Symonds (1840-1893). He was born at Bristol, educated at Harrow and Oxford, and was a Fellow of Magdalen College. He was wealthy, but had inherited consumption, and was obliged to reside at Davos-Platz, in Switzerland, for benefit of the climate. His culture was of the highest order, and to promote culture among men was his chief aim. Culture he defined as "the raising of intellectual faculties to their highest potency by means of conscious training." His greatest work, *History of the Renaissance in Italy,* in five volumes (1875-1886), treats fully of the revival of learning in the fourteenth and fifteenth centuries, the flourishing of the fine arts and literature, and the Catholic reaction which followed. The great characters, Dante, Petrarch, Boccaccio, Michael Angelo, Raphael, are described sympathetically. During his loving labor in this monumental work many essays, critical and speculative, were prepared. His *Studies of the Greek Poets* are valuable contributions to classical scholarship, full of such freshness and vigor as to commend them to the reader unacquainted with the originals. His interest in the rise of modern literature led to studies of Shakespeare's predecessors and biographies of Sir Philip Sidney and Ben Jonson. He was also fully awake to the literature of his own time, as is seen in his criticisms of Walt Whitman and Zola, both of whom he regarded as having helped man to understand himself. His original poems are light, elegant and romantic; his translations are chiefly from his favorite Italians.

Morris.—A remarkable combination of power is seen in William Morris (1834-1896). He was a true poet and artist, a promoter of household art, an ardent socialist and a successful man of business. Born near London and educated at Oxford, he was at first a painter. His first poem, *The Defense of Guinevere* (1858), was published before Tennyson's *Idylls of the King* drew attention to the Arthurian legend as material for poetry. Tennyson went to it to find a Christian hero, but Morris accepted it simply for its romantic character. Turning to Greek mythology, he composed *The Life and Death of Jason* (1867), but still retained the romantic style. *The Earthly Paradise* (1868) is a series of twenty-four narrative poems in various rhyming metres. Norse mariners in quest of Paradise find a land where descendants of the ancient Greeks dwell. Here they spend a year, during which each party recites tales from its own mythology. The Greeks tell of Atalanta, Cupid and Psyche; the Norsemen of Gudrun, Ogier the Dane and Tannhæuser. The contrast is striking and effective; the stories are picturesque and musical. Morris then undertook to recast the *Nibelungenlied* and surpassed even his previous work in *The Story of Sigurd the Volsung and the Fall of the Niblungs.* This free way of handling the ancient poetry of different races led him on to translations of Virgil's *Æneid,* Homer's *Odyssey* and, finally, the Old English *Beowulf.*

In prose Morris also accomplished similar work. With Professor Magnusson he edited the *Saga Library,* giving translations from the Icelandic. Then, enamored of this old world, he went on to compose new sagas, *The House of the Wolfings* (1889), *The Story of the Glittering Plain* (1891), *The Wood Beyond the World* (1894) and *The Well at the World's End* (1896). These prose poems recall the romance of Teutonic origins. They tell of the heroic deeds of great warriors, the loves of beautiful women. There is no attempt to introduce Christian ideas as in Tennyson's *Idylls.* All is strangely barbaric and pagan.

But Morris also wrote on art and wrought a wonderful revolution in household decoration and furniture. And from time to time he paraded the streets of London with his brother socialists, whose cause he advocated with the pen and for whom he wrote hymns. Where can be found a parallel for such a medley of achievement? "Within that circle none dare tread but he."

Stevenson.—Pathetic, yet cheering, is the story of the patient, persevering struggle of Robert Louis Stevenson (1850-1894) for literary excellence in spite of incurable disease. Born in Edinburgh of the family famous for building light-houses, he was there educated and admitted to the bar. But consumption, that fell monster, drove him from home in search of better health. He traveled on the Continent, and there began to exercise his talent for description in *Travels with a Donkey* and *An Inland Voyage.* Critics approved and the public bought his books. The charm of the *New Arabian Nights,* which first appeared in a London newspaper, was widely felt. *Treasure Island* is a tale of adventure which retains its popularity. His most famous story, *The Strange Case of Mr. Jekyll and Dr. Hyde, is* written in a homely phraseology that recalls Defoe. The double life denoted by these two names has been felt by many to express a fact seldom acknowledged. Though its power was widely recognized, Stevenson never repeated the attempt. He turned rather to the historical novel, and in *Kidnapped* and its sequel, *David Balfour,* recalled a past of Scotland different from that of Sir Walter Scott's creations. His volume of short tales called *The Merry Men* was greatly enjoyed. While issuing these novels he wrote also many essays, most charming in style, which were gathered in *Virginbus Puerisque.* Still seeking health, he had traveled across the United States and returned to Europe. There he was married to Mrs. Osborne, an American lady, who devoted herself to his comfort. They returned to California and sailed across the Pacific to remote Samoa, still in pursuit of illusive health. The balmy climate of that sunny isle awoke fresh hope. The natives of the island came to love the generous consumptive, who was able to plead their cause effectively in an international dispute. His *Vailima Letters,* so-called from his new home, are touching exhibitions of his optimistic spirit. He passed away suddenly, leaving a novel unfinished, but it was completed by an English friend. In a collected edition of Stevenson's works there were included some stories by his step-son which he had possibly revised, but which are of far different character from his own. Besides his prose writings, he published some pretty poems and delightful verses for children. His admirable style might seem spontaneous had he not recounted his diligent efforts in acquiring it, but certainly he had from the start a wonderful knack of invention.

Morley.—Literary men who have shown ability in discussing political questions are often invited to take an active part in public affairs. Such was the case of John Morley, who has done more for literature than for politics. He was born at Blackburn, Lancashire, in 1838, graduated at Oxford and was called to the bar. He became editor of the *Literary Gazette,* and in 1867 of the *Fortnightly Review,* which was intended to give opportunity for free discussion of all public questions. It proved highly successful, yet the editor found time to take charge of the *Pall Mall Gazette* also. But in February, 1883, being elected to Parliament from Newcastle-upon-Tyne, he withdrew from editorial duties except those of *Macmillan's Magazine,* which he held until 1886. In Parliament he was more successful than literary men usually are. He was an effective debater, and on the platform he became one of the chief speakers. Gladstone rewarded his services by making him chief secretary for Ireland. Morley has since shared the fortunes of the Liberal party.

To literature Morley has contributed biographical studies of the highest value—*Edmund Burke* (1867), *Voltaire* (1872), *Rousseau* (1881), and *Diderot and the Encyclopædists* (1878). His essays on historical, literary and social topics were collected in *Critical Miscellanies* (1871 and 1877). He is a sympathetic interpreter of the views and suggestions of French reformers for the amelioration of society, however vague and impracticable their schemes might be. He is himself an agnostic, yet in spite of the frankness of his utterances on religious questions he won, by his clearness of style and skill in presentations and arguments, the regard of his readers. In his later works he is more restrained and yet equally effective. Besides the writings already mentioned he published two excellent treatises—*On Compromise* (1874) and *Aphorisms* (1887). His close political association with Gladstone led that statesman to suggest that Morley should be his biographer. Abundant facilities were furnished by Gladstone's family and friends. The result is an admirable *Life of Gladstone* (1903) which does full justice to its subject. Not only is the political career fully described, but the writer, who was deeply impressed by the sincerity of Gladstone's religious faith, treats this side of his character fairly and reverently.

Lang.—The gifted Scotchman, Andrew Lang, gave promise of being an exquisite poet, but has done more as a graceful essayist and able translator of Homer and French lyrics. Anthropology, history and other important matters, as well as story writing, have claimed his attention. He was born at Selkirk in 1844, and was educated at St. Andrew's University and Balliol College, Oxford. Among his early writings were *Ballades and Lyrics of Old France* (1872). With some friends he introduced into English the forms of old French verse, ballades, rondeaus and villanelles. His *Ballades in Blue China, Ballades and Verses Vain. Rhymes Old and New,* indicate by their titles their general light, airy quality. *Helen of Troy* (1882) is his most ambitious poem. In the field of anthropology and comparative mythology Lang has been a diligent worker. To this department belong *Custom and Myth* (1884) and *Myth, Ritual and Religion* (1887). He proves that many myths, long held to be of Aryan origin, are practically found among savage tribes in various parts of the earth. His classical scholarship is shown not only in his excellent prose translations of Theocritus and Homer, but also in numerous lively essays by quotation and allusion. From foreign lands he has brought into English some fine collections of fairy tales, as in the *Blue Fairy Book* and the *Red Fairy Book.* His essays on French literature are valuable contributions to that department. In his historical romance, *The Maid of Fife* (1895), Joan of Arc is the central figure. For his editions of selections of standard literature he has written excellent introductions. For his native land he has prepared an admirable history, shedding new light on controverted points.

Barrie.—In the little group of novelists whose forte lies in depicting the peculiarities of Scotch character is James Matthew Barrie. Kirriemuir, where he was born in 1860, he has described under the name Thrums. After graduating at Edinburgh University he went to London to work as a journalist. His series of *Auld Licht Idylls* shows the stiff, stubborn character of the members of the smallest body of Scotch Presbyterians, yet awakens sympathy for their kindly nature, hidden deep under the forbidding surface. In *A Window in Thrums* the sketches of life in the little village are continued by Jess, a crippled woman, and her daughter Leeby. But Barrie's real success came with *The Little Minister* (1891), a romantic story in which a Scotch minister who undertakes to reprove and rebuke a half-gypsy girl gets so entangled that he is married to her with gypsy rites. The whirl of the incidents, the gay humor of the writer and the variety of strange characters enlist the reader's favor. *Sentimental Tommy* (1895) is a grim revelation of the miseries of child life in London, mitigated by the fancies and posings of the hero. Barrie has described the smoker's fancy for tobacco in *My Lady Nicotine.*

Ian Maclaren. — Another of the "Kail-yard Group," as these Scotch novelists have been somewhat contemptuously called, is the Rev. John Watson, who writes under the pen-name of Ian Maclaren. Though of Highland descent, he was born in 1850 in Essex, England, but was taken to Scotland in childhood. He was educated at Edinburgh University, and had for a classmate Robert Louis Stevenson. After being ordained to the ministry in the Free Church of Scotland he became pastor at a village in Perthshire, which he has described as Drumtochty. Hence he was called to Glasgow, and thence, in 1880, to take charge of a Presbyterian Church in Liverpool. His sermons exhibit his culture, as well as the liberality of his views and deep spirituality. His lectures at the Theological Seminary of Yale University were published as *The Mind of the Master.* In his story *Beside the Bonnie Brier Bush* (1894), the characters of the ambitious scholar, of his loving mother and of Doctor William Maclure strongly touched the hearts of the people. In *The Days of Auld Lang Syne* other sketches of Drumtochty were presented. In *Kate Carnegie* (1896) the theological disputes do not exclude truly religious feeling. Dr. Watson's combination of droll humor with genuine religious sentiment has given him his deserved popularity. *Margaret Ogilvy,* an exquisite idyll of a mother's love, is the story of his own mother.

Kipling.—Rudyard Kipling is the son of John Lockwood Kipling, principal of the school of industrial art at Lahore, and was born at Bombay, India, in 1865. He was sent to school in England, but returned to India in 1882 and became subeditor of a newspaper at Lahore. His hastily written stories and verses were circulated through India. From them were gathered *Plain Tales from the Hills,* which were published in England and received with delight. In 1889 Kipling went to England and soon afterward made a tour across the United States, writing descriptive letters as he journeyed. He married the sister of Wolcott Balestier, with whom he had collaborated in a novel, *The Naulahka* (1892), and settled at Brattleboro, Vermont, for a few years. After a serious illness he went back to England in 1897.

Besides his Anglo-Indian stories, Kipling produced a new kind of fables in *The Jungle Book* (1894). These are dialogues and stories of the life of the wild beasts of India from their own point of view. Compared with Æsop's simple moralizings and the grotesque German stories of *Reineke Fuchs,* these jungle stories are both realistic and ethical. *The Light That Failed* (1890), Kipling's first novel, included a graphic account of an Egyptian campaign, with a sketch of studio life in London. In *Captains Courageous* (1897), the breezy narrative of the perilous adventures of the fishermen of Gloucester, and in some short stories, Kipling utilized his observations in America. His poems, even the coarse soldiers' ballads, are full of imagination and patriotism. His *Seven Seas* glorified British imperialism; contrary to his wont of boasting, his *Recessional,* written for the sixtieth anniversary of Queen Victoria's accession, was a humble appeal for Divine favor; *The Truce of the Bear* was the British scornful response to young Czar Nicholas' suggestion for the disarmament of nations; *The White Man's Burden* was a thrilling declaration of the duty of the superior race to the inferior; *The Absent-Minded Beggar* was a rousing call to Englishmen at the opening of the Boer war. In all of these he was a new and true voice of England.

Kipling himself went to South Africa in the height of the conflict as a correspondent for newspapers. But there seemed to be thenceforth a decided falling off in his work. His letters were mere chatter. After his return he published *Starkey and Co.,* an unpleasant tale of school life. The new fables of animal life are ridiculously feeble. But in his *Kim* he recovered his power of presenting to Western readers the manifold life of the East. In recent years he has ceased from his phenomenal productivity and has lost his once firm hold on public attention. It seems impossible that his wonderful genius should be exhausted before he has reached the age of forty.

Austin.—In 1895 Lord Salisbury, on behalf of the British government, bestowed on Alfred Austin the laureateship left vacant since the death of Lord Tennyson. Austin was then sixty years old, and had been active in literature for many years. He was born near Leeds, of Roman Catholic parents, and was educated at Stonyhurst College and St. Mary's, Oscott. Of his early poems a satire called *The Golden Age* had the most success. There were also dramatic, lyric and narrative poems, of which the best were *The Human Tragedy. Rome or Death* (1873), and *Savonarola* (1881). Though striking no high note, he showed strong patriotic feeling. *England's Darling* is a eulogy of Alfred the Great. *The Garden I Love* attests his love of nature. His poem on Dr. Jameson's ride was intended to express English sympathy, but under the circumstances seemed foolish. At the opening of the Boer war his attempt to voice the national feeling was thrown into the shade by Kipling's bolder lyrics. In later poems he has copied the manner of this popular rival, without reaching his vigor.

Dobson.—Among the minor poets who have enriched English literature with new forms of verse derived from Old French is Austin Dobson. He was born at Plymouth and educated at Coventry and Strassburg, with the expectation of becoming a civil engineer. But he became a clerk in the Board of Trade and remained in its service till 1902. In 1868 he set the fashion of poems in the artificial metres used by the French poets of the Renaissance, rondeaus, ballades and villanelles. Of this style were his *Vignettes in Rhyme* (1873), *Old World Idylls* (1883) and *At the Sign of the Lyre* (1895). He has also a delicate vein of satire. He has done much for biography of English writers of the eighteenth century, as Fielding, Steele, Goldsmith and Horace Walpole. To these may be added lives of the painter Hogarth and the wood-engraver Bewick and *Eighteenth Century Essays.* All he writes is characterized by a polished grace and deftness of touch.

Gosse.—Excellent both as lyric poet and critic, Edmund William Gosse has also contributed much to the history of English literature. He was born in London in 1849, the son of Philip H. Gosse, a distinguished naturalist. At the age of eighteen he became an assistant in the British Museum, and in 1875 translator to the Board of Trade. He is proficient in the languages of Northern Europe. His *Northern Studies* brought the literature of Sweden and Norway to the knowledge of English people. In 1884 he was made lecturer in English literature at Trinity College, Cambridge. He also visited the United States and lectured in the principal colleges. His poems are usually short lyrics, as in *Madrigals, Songs and Sonnets* (1870), *On Viol and Flute* (1873) and *The Secret of Narcisse* (1892). His literary studies have been chiefly in the writers of the seventeenth and eighteenth centuries. He has written biographies of Congreve and Dr. John Donne. With Richard Garnett he has edited an *Illustrated History of English Literature.*

Watson.—Among the poets seriously mentioned as fit to succeed to the laureateship left vacant by Tennyson was William Watson. Unfortunately, a mental trouble about that time required his removal to an asylum. He afterward entirely recovered. Watson was born at Wharfdale, in Yorkshire, in 1850. He was the son of a Liverpool merchant, and was educated privately. His favorite studies were the poems of Shelley, Keats and Wordsworth. His own poem on *Wordsworth's Grave* (1892) called forth general approval, which was also accorded to his tribute to Tennyson's memory, *Lachrymæ Musarum* (1892), and his *Tomb of Burns* (1897). For this the government awarded him a pension of £200. *The Purple East,* which was afterward enlarged into *The Year of Shame,* was a series of sonnets, upraiding the English for their neglect of the Armenians in 1896. These ringing sonnets recall Milton's vehement denunciation of the persecution of the Vaudois. Watson published the poems which he had written while afflicted with depression. During the Boer war he lost popular favor by condemning the course of the British government.

Mrs. Humphry Ward.—A writer who seemed for a time to have succeeded to the place of George Eliot was Mrs. Mary Augusta Ward. She was born at Hobart Town, in remote Tasmania, in 1851, the daughter of Thomas Arnold, and granddaughter of the famous Dr. Arnold, of Rugby. The family soon removed to Oxford, England, and Mary was thoroughly educated. Her husband Thomas Humphry Ward, was the editor of many useful compilations. Her first novel, *Miss Bretherton* (1884), told the growth of love between a young actress and a middle-aged literary man. *Robert Elsmere* (1888) portrayed the gradual loss of religious faith in a highly educated person through the skeptical tendency of the times. *The History of David Grieve* (1892), on the other hand, showed the growth of faith in a humbler hero. In *Marcella* (1894) a worthy leader of society is developed from a romantic girl. She appears again in *Sir George Tressady* (1896), as victorious over temptation. *Helbeck of Bannisdale* (1898) is a tragic picture of religious struggle.

Scientific Writers.—A large part of the books published in any age are intended to state and disseminate the knowledge which has been acquired up to that time. They are school books, works of information, works of science, encyclopedias. Such works necessarily become obsolete from one generation to another, because science is steadily advancing, and knowledge increasing. This has been especially the case in the nineteenth century, which has witnessed the rise and development of many new branches of science. In general such works, however useful and indispensable, are excluded from consideration in a history of literature. And yet there have been some scientific writers whose work has had such wide and lasting influence on the minds and thought of their age that they seem to belong to a higher class, and to deserve to be enrolled in what De Quincey has distinguished as the literature of power, that literature which so deals with the immortal part of man that it never becomes obsolete.

To this higher class of scientific works belong the writings of Darwin and Herbert Spencer, and in a less degree those of Tyndall and Huxley. The doctrine of evolution was put forth scientifically by Charles Robert Darwin, about 1859, after careful researches conducted for many years. It was taken up and extended philosophically by Herbert Spencer, who claimed, indeed, to have founded a new synthetic philosophy, which would supersede all old systems of science. This doctrine roused at first fierce opposition and active controversy. It was gradually admitted as correct in many applications, though there was still dispute as to the extent of the theory. As soon as it was generally accepted, the new theory was found to have effect not only on natural science but on history, on ethics, on religion. New writers and new publications arose to advocate and apply it in every direction. It had a strange effect in rousing curiosity about the customs and beliefs of savage tribes, and thus gave rise to folk-lore. It helped to increase travel and exploration of the world. All this activity was reflected in the pages of literature. It was treated by light essayists as well as thoughtful philosophers, by the ambitious novelist and by the imaginative poet.

But however wide-reaching the effects of this theory, the works of Darwin still must be regarded as belonging to science, and liable to be superseded by the labors of scientists of the twentieth century. But his cautious method and his life-long devotion to the pursuit of scientific truth are worthy of all praise. The teachings of Herbert Spencer even before his death had lost much of their power. His broad generalizations were found too sweeping. They failed to take into account some important factors in human progress. Some portions of Spencer's grand scheme of social statics have been utilized by others, but in the main it has been neglected. In his later years he discussed the social and political questions of the day, and appeared as a Tory individualist, while the general current of thought was tending to Socialism.

Twentieth Century.—The outlook for the new century in literature is bright and hopeful. The pessimism which darkened the latter part of the nineteenth century has been largely dispelled. Essayists no longer discuss the question, "Is life worth living?" They have new themes inspiring thought and stimulating action. Romanticism, which had been expelled from fiction by gloomy realism, has returned to win new triumphs. History, assisted by deeper research, promises new achievements in both the ancient and the modern world. The lyric poets sing sweet songs as of old, and there is yet room for a grand epic.

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Gibbon, Edward.
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Gray, Thomas.
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HISTORIC LANDMARKS OF THE ENGLISH LANGUAGE

		A. D.
1.	**The Beowulf,** an old English epic, "Written on the mainland"	450
2.	**Christianity** introduced by St. Augustine, and with it many classical words	597
3.	**Caedmon**—"Paraphrase of the Scriptures," the first English poem	670
4.	**Baeda,** known as "The Venerable Bede," translated part of the Gospel of St. John into English	735
5.	**King Alfred** translated several Latin works into English	901
6.	**Aelfric, Archbishop of York,** turned into English most of the historical works of the Old Testament	1000
7.	**The Norman Conquest** introduced many Norman French words into the English speech	1066
8.	**Anglo-Saxon Chronicle,** said to have been started by King Alfred, closed in	1160
9.	**Orrmin's Ormulum,** a poem written in the East Midland dialect, about	1154
10.	**Normandy** lost under King John, and the Norman-English begin to use the English speech more and more	1204
11.	**Layamon** translates the "Brut" from French into English. This was the first book written in English after the stoppage of the Anglo-Saxon Chronicle	1205
12.	**The Ancren Riwle** (Rules for Anchorites), written in English, was the forerunner of a great change in English speech	1220
13.	**First Royal Proclamation in English,** issued by Henry III	1258
14.	**Robert of Gloucester's Chronicle,** abounding in foreign terms	1297
15.	**Robert of Brunn** (Robert Manning), compiled the "Handlyng Synne"	1303
16.	**The Remorse of Conscience** (Ayenbite of Inwit)	1340
17.	**After the Great Plague,** French was spoken less and less	1349
18.	**Sir John Mandeville** used the newer English prose in writing his "Travels"	1356
19.	**English** becomes the language of the Law Courts	1362
20.	**Wicklif's** translation of the Bible	1380
21.	**Geoffrey Chaucer's** poem entitled the "Canterbury Tales"	1400
22.	**William Caxton,** printer, brings out "The History of Troy," the first English book ever printed. It was printed in the Netherlands	1471
23.	**Caxton** prints "The Game and Playe of the Chesse," the first English book printed in England	1474
24.	**Lord Berner** translates Froissart's Chronicle	1523
25.	**William Tyndale** fixes the English speech once for all by his translation of the Bible.	1525–1534
26.	**Edmund Spenser's** "Faerie Queene" began the golden age of English literature	1590
27.	**King James'** version of the Holy Bible further fixed the standards of English speech	1611
28.	**William Shakespeare,** in his works, carried English speech to great perfection	1616
29.	**John Milton** in his "Paradise Lost" gave English speech a highly classical turn	1667
30.	**The Revised Prayer Book** helped greatly to the modern form of English speech	1661
31.	**John Bunyan's** "Pilgrim's Progress" served to show the wealth of the English language in pithy idioms	1688
32.	**Sir Thomas Browne's** "Urn Burial," and other works, showed a reaction from simple to classical English	1642
33.	**Dr. Samuel Johnson** in his "Rasselas" and other works used a very pompous style of English	1759
34.	**Alfred Tennyson,** in his poems, did much for the revival and establishment of the purest style of English . . . . Born	1809

AMERICAN
LITERATURE

Colonial Period to
The Present Time

History, Story and Song
Lives of All Our Noted Authors
Analyses of their Styles and Works

BY

JOHN P. LAMBERTON, A. M.

CREATORS
OF
AMERICAN LITERATURE

THE WORKS THAT HAVE IMMORTALIZED AUTHORS THROUGH THE FOUR GRAND ERAS OF LITERARY PROGRESS

MENTION OF A FEW OF THE VERY MANY

I. The Colonial Period.

Captain John Smith (1579-1631)
Roger Williams (1606-1683)
John Winthrop (1587-1649)
Anne Bradstreet (1612-1672)
Cotton Mather (1663-1728)
Jonathan Edwards (1703-1758)
John Woolman (1720-1772)
Benjamin Franklin (1706-1790)

II. Revolutionary Period

John Dickinson (1732-1808)
John Witherspoon (1722-1794)
John Trumbull (1750-1831)
Francis Hopkinson (1737-1791)
Thomas Paine (1737-1809)
Alexander Hamilton (1757-1804)

III. National Period

Charles Brockden Brown (1771-1810)
Washington Irving (1789-1859)
James Fenimore Cooper (1789-1851)
William Cullen Bryant (1794-1878)
Lydia Maria Childs (1802-1880)
Ralph Waldo Emerson (1803-1882)
Edgar Allen Poe (1809-1849)
Nathaniel Parker Willis (1806-1867)
Henry Wadsworth Longfellow (1807-1882)
James Russell Lowell (1819-1891)
Oliver Wendell Holmes (1809-1894)
John Greenleaf Whittier (1808-1892)
Nathaniel Hawthorne (1804-1864)
George Bancroft (1800-1891)
Harriet Beecher Stowe (1812-1886)
Bayard Taylor (1825-1878)
Thomas Buchanan Read (1822-1872)
Donald G. Mitchell (Ik Marvel, 1822 —)

IV. Modern Period

Sidney Lanier (1842-1881)
Walt Whitman (1819-1892)
Helen Hunt Jackson (1831-1885)
Francis Bret Harte (1839-1902)
William D. Howells (1837 —)
George W. Cable (1844 —)
Henry James (1843 —)
Edward Eggleston (1837-1903)
John Bach McMaster (1852 —)
Henry Cabot Lodge (1850 —)
Theodore Roosevelt (1858 —)
Thomas Bailey Aldrich (1837 —)
Lewis Wallace (1827 —)
Julien Hawthorne (1846 —)
Edward Everett Hale (1822 —)
Samuel L. Clemens (Mark Twain, 1835 —)
Joel C. Harris (1848 —)
Will Carleton (1845 —)

AMERICAN LITERATURE

THE COLONIAL PERIOD.

1607—1765.

THE FIRST ENGLISH SETTLEMENT. Not until a hundred years had passed after John Cabot, by his discovery of North America in 1497, had laid the foundation for England's claim to this country, was any attempt made by English people to occupy it. Then the gallant Sir Walter Raleigh undertook the enterprise, but the result was a disastrous failure. A little remnant of his feeble band on Roanoke Island was absorbed among the Indians. In 1607 the enterprising merchants of London sent out a stronger company under better auspices to found Jamestown, in Virginia. English preachers and poets exerted their talents to set forth the brilliant prospects of the new venture. Yet even this glowingly advertised scheme was in danger of failure from the inevitable but unforeseen difficulties of planting civilization in a wilderness. At last, after a hard struggle and with liberal help from its wealthy promoters, it did succeed, not in financial returns, but in making a new home for English men and English institutions. In the course of the seventeenth century ten more such colonies were established with similar struggles and little mutual aid. In fact there was often rivalry and jealousy among them, which only the common danger from the savage Indians or the more formidable French could suppress for a time.

CHAPTER I.

The Colonial Period. 1607-1765.

Colonial Literature.—Amid the pressing hardships of new settlements few of the immigrants had time or inclination to produce literature. Yet there were writers who reported to their English friends the natural features of the New World and the character of its inhabitants and told the story of their own adventures among them. There were preachers who employed pen, as well as voice, to preserve and promote that form of the Christian religion which they had brought to a strange land. There sprang up also in the colonies, here and there, men who found fault with the newly framed governments and customs and indulged in satirical comments. All this was in plain prose, often the plainest and roughest, preserved only for its historical interest, and as testifying the spirit of our rude forefathers. Yet there were some feeble attempts at verse-making, which now excite a pitying smile rather than give intellectual pleasure. Such is the general aspect of colonial literature until the English government, seeing the growing importance of the colonies, without appreciating their circumstances or their spirit, began to impose new burdens, too grievous to be borne. The Stamp Act of 1765 swept nearly all minds in the several colonies into the same current of thought. From that date began the conscious unity of the American people, which was soon reflected in their literature, openly declared in Congress, and successfully maintained in the field.

Captain John Smith.—Among the first settlers of Virginia was a hardy adventurer, bearing the homeliest of English names, John Smith (1579-1631). He spent only two years and a half in the country, and for part of that time was president of the colony, though at first he was regarded as a disturber of its peace. According to his own report, he was the means of keeping the settlers from abandoning Jamestown and of saving them from starvation. Being injured accidentally he was obliged to return to England, and there published various treatises. He had already issued *A True Relation of Virginia* (1608), which he afterward enlarged into a *General History of Virginia* (1624). In the former he said piously: "We doubt not but by God's gracious assistance, and the adventurous willing minds and speedy furtherance to so honorable an action, in after-times to see our nation enjoy a country not only exceedingly pleasant for habitation but also very profitable for commerce in general, no doubt pleasing to Almighty God, honorable to our gracious sovereign, and commodious generally to the whole kingdom."

Smith was a rough copy of Sir Walter Raleigh, a man of low birth but aspiring to great things. In his writings he did not hesitate to exaggerate his own exploits and appropriate to himself the credit properly belonging to others. In his *True Relation* he tells of his capture by Powhatan and six weeks' captivity, but says nothing about his famous rescue by Pocahontas. That dramatic episode was a happy thought first published after the Indian princess was brought to England, in 1616, as the wife of John Rolfe, and was presented at court. While critical historians generally dismiss the story as fiction, it must be admitted that John Fiske and others accept it as fact, somewhat colored.

CAPTAIN SMITH RESCUED BY POCAHONTAS.

(From Smith's *General History of Virginia*, slightly modernized.)

At last they brought Smith to Meronocomoco, where was Powhatan, their emperor. Here more than two hundred of those grim courtiers stood wondering at him, as he had been a monster, till Powhatan and his train had put themselves in their greatest braveries. Before a fire, upon a seat like a bedstead, he sat, covered with a great robe made of raccoon-skins, and all the tails hanging by. On either hand did sit a young wench of sixteen or eighteen years, and along on each side the house two rows of men, and behind them as many women, with all their heads and shoulders painted red, many of their heads bedecked with the white down of birds; but every one with something; and a great chain of white beads about their necks.

At Smith's entrance before the king, all the people gave a great shout. The Queen of Appamatuck was appointed to bring him water to wash his hands; and another brought him a bunch of feathers, instead of a towel, to dry them. Having feasted him after the best barbarous manner they could, a long consultation was held; but the conclusion was, two great stones were brought before Powhatan. Then as many as could laid hands on him, dragged him to them, and thereon laid his head, and being ready with their clubs to beat out his brains, Pocahontas, the king's dearest daughter, when no entreaty could prevail, got his head in her arms, and laid her own upon his, to save him from death. Whereat the emperor was contented he should live to make him hatchets, and her bells, beads, and copper; for they thought him as well of all occupations as themselves. For the king himself will make his own robes, shoes, bows, arrows, pots; plant, hunt, or do anything so well as the rest.

Two days after, Powhatan, having disguised himself in the most fearfulest manner he could, caused Captain Smith to be brought forth to a great house in the woods, and there, upon a mat by the fire, to be left alone. Not long after, from behind a mat that divided the house was made the most dolefulest noise he ever heard; then Powhatan, more like a devil than a man, with some two hundred more as black as himself, came unto him, and told him now they were friends, and presently he should go to Jamestown, to send him two great guns and a grindstone, for which he would give him the country of Capahowosick, and forever esteem him as his son Nantaquond. So to Jamestown with twelve guides Powhatan sent him. That night they quartered in the woods, he still expecting—as he had done all this long time of his imprisonment—every hour to be put to one death or other, for all their feasting. But Almighty God by his divine providence had mollified the hearts of those stern barbarians with compassion. The next morning betimes, they came to the fort, where Smith, having used the savages with what kindness he could, he showed Rawhunt, Powhatan's trusty servant, two demi-culverins and a millstone, to carry Powhatan.

Early Virginia Writers.—There were others connected with the settlement in Virginia who wrote accounts of its affairs. Some of these were published at the time; others were intended for the information of the Virginia Company of London, which supported the enterprise for several years, until it passed into the King's hands. There were factions among the leaders, and few of the settlers were qualified for the labor required. Grumblings and quarrels marked every stage of its progress. Even after the various documents have been carefully sifted, historians are not fully agreed in awarding praise and blame among the parties. Jamestown was built on a small island, and hardly a vestige of it remains. But the colony eventually, by raising tobacco, became wealthy and took the lead in more important matters.

Among the early writers were George Percy, who describes the brightness and gloom of the first year in Virginia; William Strachey, whose picture of a storm on his disastrous voyage thither is thought to have suggested Shakespeare's *Tempest;* the missionary, Alexander Whitaker, who wrote *Good News from Virginia,* and John Pory, who gives amusing sketches of Indian life. The most remarkable literary fact connected with the early settlement is that George Sandys, amidst severe calamities which threatened to destroy the colony, persevered in translating into English verse Ovid's *Metamorphoses.* The work was published in 1626, after his return to England.

The Pilgrims at Plymouth.—In December, 1620, a weather-beaten band of a hundred souls landed on the stern and rock-bound coast of New England. They were Independents in religion, who had previously been driven from the vicinity of Scrooby, in Yorkshire, England, to take refuge in Holland. Their leaders had tedious negotiations with the Plymouth Company, who held a royal patent for settling colonies in New England. Two vessels were chartered, but only one—the historic "Mayflower"—was able to cross the ocean. Its passengers were poor, but intelligent and deeply religious people, willing to undergo hardship for conscience sake. From their study of the Bible they desired a return to the primitive simplicity of apostolic times, and more thorough reformation in religion than had been attained in England. Before they landed they drew up and signed the celebrated "Mayflower Compact," forming themselves into a "civil body politic."

William Bradford.—One of the most influential Pilgrims was William Bradford (1588-1657). He was elected Governor in 1621, and thereafter annually for thirty-one years. Beginning in 1631, he wrote a *History of Plymouth Plantation,* whose fate was singular. The manuscript was long preserved in the Old South Church in Boston, but was carried away when the British evacuated that city in 1775. Taken first to Halifax, and afterward to London, it was kept in the Lambeth library, but was practically unknown. When discovered, in 1853, it was called "The Log of the Mayflower." Much public interest was aroused, and it was copied and published. Eventually, by the good offices of Hon. T. F. Bayard, the manuscript was restored to the State of Massachusetts, in whose custody it remains. It is really a history of the colony from 1602 to 1647. The author was modest in his statements about himself. He said at the outset, "I shall endeavor to manifest the history in a plain style, with single regard unto the simple truth in all things, at least as near as my slender judgment can attain the same." This purpose he fully carried out. Though the history was not published till two centuries had passed, it had been used by his nephew in a fuller history, and later by Thomas Prince. But since it has been accurately printed, it has been pronounced a classic in historical literature.

THE LANDING OF THE PILGRIMS.

(Modernized from Bradford's *History of Plymouth Plantation*, also called *The Log of the Mayflower.*)

[Dec. 8, 1620.] It began to snow and rain, and about the middle of the afternoon the wind increased and the sea became very rough. They broke their rudder, and it was as much as two men could do to steer her with a couple of oars. But their pilot bade them be of good cheer for he saw the harbor. But the storm increasing and night drawing on, they bore what sail they could, to get in while they could see. But herewith they broke their mast in three pieces and their sail fell overboard in a very grown sea, so as they had like to have been cast away. Yet by God's mercy they recovered themselves, and having the flood with them struck into the harbor. But when it came to, the pilot was deceived in the place and said the Lord be merciful to them, for his eye never saw that place before, and he and the master-mate would have run her ashore, in a cove full of breakers before the wind, but a lusty seaman which steered bade those which rowed, if they were men, about with her, or else they were all cast away; the which they did with speed. So he bid them be of good cheer, and row lustily for there was a fair sound before them, and he doubted not but they should find one place or other, where they might ride in safety. And though it was very dark, and rained sore, yet in the end they got under the lee of a small island, and remained there all the night in safety. But they did not know this to be an island till morning, but were divided in their minds; some would keep the boat for fear they might be amongst the Indians; others were so weak and cold they could not endure, but got ashore, and with much ado got fire (all things being so wet), and the rest were glad to come to them, for after midnight the wind shifted to the northwest, and it froze hard.

But though this had been a day and night of much trouble and danger unto them, yet God gave them a morning of comfort and refreshing (as usually He doth to His children); for the next day was a fair sun-shining day, and they found themselves to be on an island secure from the Indians; where they might dry their stuff, fix their pieces (guns), and rest themselves, and gave God thanks for His mercies in their manifold deliverances. And this being the last day of the week, they prepared there to keep the Sabbath. On Monday they sounded the harbor and found it fit for shipping, and they marched into the land and found divers cornfields and little running brooks, a place (as they supposed) fit for situation (settlement); at least it was the best they could find, and the season and their present necessity made them glad to accept of it. So they returned to their ship again with this news to the rest of their people, which did much comfort their hearts.

On the 15th of December they weighed anchor to go to the place they had discovered, and came within two leagues of it, but were fain to bear up again. But the 16th day the wind came fair, and they arrived safe in the harbor. Afterward they took better view of the place, and resolved where to pitch their dwelling. And the 25th day they began to erect the first house for common use to receive them and their goods.

[NOTE.—The first landing, as shown above, was made on December 10th, old style, which becomes the 21st in the new style. By error in calculation it has been reckoned to be the 22d, which day is usually celebrated.]

Independents and Puritans.—The Pilgrim Fathers who had settled at Plymouth were Independents in religion, that is, they had definitely withdrawn from the established Church of England before they left that country. They held that to form a Christian church anywhere all that was necessary was for a number of those who believed in salvation by Christ to unite by a covenant to assist each other in following Him. Each congregation could act by itself in selecting and ordaining its teachers and ministers. But the later immigrants who settled at Boston and Salem were Puritans, strongly attached to the national church, yet desiring its further reformation. They were Calvinists in doctrine, and wished to keep in communion with the Protestant churches of the Continent. They tended to the Presbyterian system of church polity, and objected to certain usages in worship as superstitious, while they sought to enforce stricter morality among the members. But the bishops resisted their efforts, and insisted on conformity to the established rites and ceremonies. When the Puritans would not comply, they were prosecuted for non-conformity and their clergymen were prohibited from preaching.

Under these circumstances several prominent Puritan pastors, with their flocks, sought refuge in New England and formed the Massachusetts colony, entirely distinct in government and spirit from the Plymouth colony. The new-comers were, in general, more wealthy and better educated than their predecessors. Their love of learning was shown in their prompt effort to establish a college at Cambridge, named from the English Cambridge at which many of them had received their education. A printing press was set up under the charge of the college, to help in maintaining the intelligence necessary in conducting the affairs of the settlement in the wilderness. Yet the sermons and larger treatises of the Puritan divines were usually printed in England, that they might be circulated in England as well as in their new home. They were not without hope that their principles would yet prevail in the mother country. The Presbyterians did for a time control Parliament and waged war on the king, but their leaders proved incapable and were obliged to make way for the Independent Cromwell. When that great ruler passed away, the nation, tired of strife, sought peace in the restoration of monarchy. The Puritans in England were persecuted more bitterly than before. The colonists in Massachusetts were weaned from their lingering fondness for the mother country. By force of circumstances they had become Congregationalists, but they still maintained the union of Church and State as necessary. They denounced religious toleration as sinful. They expelled all who taught doctrines not approved by their ministers. Sharp disputes on such matters exercised their wits, and fill the pages of their history.

Religious Literature.—The first book printed in the colonies was *The Bay Psalm Book* (1640), issued from the press at Harvard College. Its title and contents show at once what was the popular demand. The immigrants had brought their Bibles, and more could be imported. But the homely, literal version of the Psalms which they needed for singing at home, as well as at church, they must supply themselves. Their preachers were learned men and published sermons, controversial treatises and narratives of mission work among the Indians. Thomas Hooker (1586-1647), Thomas Shepard (1605-1649) and John Cotton (1585-1652) were the chief of this class, all graduates of Cambridge University, England. Hooker had been silenced by Archbishop Laud for nonconformity, and when he came to Massachusetts in 1633 had the reputation of being "without an equal either in preaching or in disputation." He was pastor of the church at Cambridge for three years and then removed to Hartford to help in founding the colony of Connecticut. Some difference of opinion about the religious qualification of voters led to this movement. After Hooker's death about a hundred of his sermons were published in London. His principal work was *A Survey of the Summe of Church Discipline.* This title shows at once what was preëminent in the minds of the founders of the new colony—the regulation of the Congregational Church and its relation to the State.

Shepard was another exile. He arrived at Cambridge, Massachusetts, in 1635, and in the next year became pastor of the church which Hooker had left. He wrote many religious treatises in an earnest, energetic style. His hopeful interest in missionary efforts among the Indians is shown in *The Clear Sunshine of the Gospel Breaking Forth Upon the Indians of New England.* The affectionate feeling of the Puritans for the mother country, and their continued interest in it, are expressed in *New England's Lamentation for Old England's Errors.*

But the most distinguished of these scholarly exiles was John Cotton. Before he left Emanuel College, Cambridge, he had risen to be its dean. He was an eloquent preacher, and his elaborate sermons attracted large audiences at the university, but when he became a devoted student of Calvin his popularity waned. He took charge of St. Botolph's Church at Boston, in Lincolnshire, and thence his fame as a pulpit orator spread through England. But when William Laud became primate, Cotton was doomed. The Earl of Dorset sent him a message that if he had only been guilty of drunkenness or adultery, or any such minor offense, he might have been pardoned; but, since his crime was Puritanism, he must flee for his life. Cotton arrived at Boston, in Massachusetts, in 1633. That town had been named as a compliment to the Puritan preacher, and he was called to be pastor of its church. For twenty years he held this position, and was as prominent in civil affairs as in ecclesiastical. He corresponded with Cromwell in the height of his power. Carlyle, in mentioning the fact, describes the preacher as "oracular of high gospels to New England." Cotton wished to make the colony a theocracy, and drew up and caused to be printed in London a code of laws based on the Mosaic laws. But the Puritan commonwealth, with true wisdom, never adopted these laws, yet they have been erroneously quoted as the laws of Massachusetts. For his congregation he wrote *Of the Holiness of Church Members*, for their children he prepared a catechism called *Spiritual Milk for Babes.* He wrote expositions and commentaries on books of the Bible; discussed *Set Forms of Prayer* and *The Keys of the Kingdom of Heaven*, and pronounced *Singing of Psalms a Gospel Ordinance.* But the writing which is chiefly referred to is his reply to Roger Williams' *The Bloody Tenent of Persecution for Cause of Conscience.* Williams, in opposition to the general belief and practice of that age, declared that the civil magistrate had no right to interfere in matters of religion. The very title of Cotton's reply shocks a reader of the present day: *The Bloody Tenent Washed and made White in the Blood of the Lamb.* But the humane, yet stubborn, Roger retorted with *The Bloody Tenent yet more Bloody by Mr. Cotton's Endeavor to wash it White in the Blood of the Lamb.* The victory in the controversy undoubtedly remains with Williams' earnest treatise, often lumbering and diffuse in style, yet exhibiting learning, pathos, sarcasm and lofty imagination.

Roger Williams.—The humbly pious, but restless and courageous, Roger Williams (1606-1683) was born in Wales and educated at Oxford. For a time he was a clergyman of the Established Church, but when he became convinced secular governments should not meddle with religion he resigned his orders. In 1631 he came to Plymouth and preached. Two years later he was called to Salem. His preaching was attractive, but he disturbed the peace of the community by publishing a pamphlet asserting that the Indians had the right to the soil; that the king could not grant a title, but the soil must be bought from the Indians. His course was so obnoxious to the authorities that he was tried and banished. Therefore, in midwinter he sought refuge among the Indians, who knew his friendly disposition. His settlement, piously named Providence, became a haven of soul-liberty, as he called his doctrine.

In 1643 the four colonies—Plymouth, Massachusetts, Connecticut and New Haven—for mutual protection formed a confederacy called "The United Colonies of New England." Williams' settlement, which had steadily grown, was left out. He, therefore, went to London to procure a charter. There he found plenty to do, as the Westminster Assembly of Divines was in session. Upon them he urged consideration of his new doctrine, presenting it first in the form of queries. Afterward, waxing bolder, he published the treatise already mentioned, *The Bloody Tenent of Persecution for Cause of Conscience* (1644). Having secured the charter for Rhode Island and the Providence plantations, Williams returned to his colony and was made its president. It was after this that the apostle of religious liberty became a Baptist. He had other controversies with Cotton besides the one about persecution. Long afterward he published at Boston a full report of the debates he had with certain Quakers. This large book he called *George Fox digged out of his Burrows* (1676), and in it he used vituperation and scurrility to a surprising extent. This restless controversialist was yet a mild-tempered Christian, and called his offensive words "sharp Scripture phrases." His doctrine of soul-liberty is deeply imbedded in American institutions.

John Eliot (1602-1690), famous as "The Apostle to the Indians," was a graduate of Cambridge University, and after coming to Massachusetts settled at Roxbury as a preacher. For the Indians he translated into their language the Bible and other religious works.

John Winthrop (1587-1649), the first governor of Massachusetts, left a manuscript history which was used by later historians, but not entirely published till 1826. He had been a justice of the peace in Suffolk, England, before he was chosen leader of the colony which settled at Salem in 1630. From year to year he was chosen governor, except when he declined the office.

A fantastic light is cast on the Pilgrims by the actions and writings of Thomas Morton, an English lawyer, who came to Plymouth in 1622, rather in the spirit of frolic. He founded a settlement at Mount Wollaston, which he called Ma-re Mount (Merry Mount). Here he set up a Maypole and celebrated games which scandalized the sober Pilgrims. Being charged with furnishing firearms to the Indians, he was arrested by Captain Miles Standish, whom he calls Captain Shrimp. But the culprit escaped and returned to Ma-re Mount. He was again arrested and sent back to England, but soon returned to repeat his tricks. His book reciting his merry adventures was published in 1637. It is full of humor and has some marvelous natural history.

Mrs. Anne Bradstreet.—Highly honored in her day was Mrs. Anne (Dudley) Bradstreet (1612-1672). She was the daughter of Governor Thomas Dudley and wife of Simon Bradstreet, who also became governor of Massachusetts. When her poems were printed at London the publishers prefixed the title *The Tenth Muse lately sprung up in America* (1650). They were chiefly didactic, imitating the style of Du Bartas and Quarles, but the last was a political dialogue between Old and New England. An improved edition was issued at Boston in 1678, with some simpler and more original verses.

Wigglesworth.—For fifty years, in spite of weak health, Rev. Michael Wigglesworth (1631-1705) was pastor at Meldon. He issued three poems of considerable length. One was *God's Controversy with New England* (1662), written at a time of great drought, and describing New England as "planted, prospered, declining, threatened, punished." According to his notion, America had been a habitation of devils before the arrival of the English settlers. Another poem consisted of meditations on the afflictions of God's children; it was quaintly called *Meat out of the Eater* (1669), a title borrowed from Samson's riddle. But his most astonishing production was *The Day of Doom,* describing the last Judgment according to the severest Puritanical theology. This sulphurous poem long remained strangely popular, and was hawked about the country on broadsides.

Increase Mather.—The family of the Mathers was influential in New England for three generations. Richard Mather (1596-1669) was a graduate of Oxford and a clergyman in England. He was prohibited by Archbishop Laud for not wearing a surplice when preaching. Thereupon he set sail for Boston and became pastor at Dorchester in 1636. He wrote the preface to the *Bay Psalm Book* and many controversial and religious treatises. His son, Increase Mather (1639-1723), after graduating at Harvard, went for further study to Trinity College, Dublin, and became a preacher in England. Returning to America, he became pastor of the North Church in Boston. By his learning, industry and ambition he became the autocrat of Massachusetts. He went to England and spent some years trying to regain the charter which secured to the colony self-government. For sixteen years he was president of Harvard College. His best-known work is *An Essay for the Recording of Illustrious Providences.*

Cotton Mather.—More eminent than his father was Cotton Mather (1663-1728), who was also the grandson of John Cotton. He graduated from Harvard at the age of fifteen, and was ordained when twenty-one. His industry was great and his learning marvelous. The praises of the people ministered to his vanity, yet there must have been some distrust of him, for he never reached the presidency of Harvard College, which he earnestly desired. Nearly four hundred publications are ascribed to him. His greatest work is *Magnalia Christi Americana* (1702), "the great works of Christ in America." It was intended to record the ecclesiastical history of New England, somewhat like Fuller's *Church History.* It abounds in quaint pedantry, odd expressions and even puerilities, yet it is the most important historical production of the colonial period. Its chief excellence is in description of characters. Mather's fame has been seriously injured by the part he took in the agitation of the Salem witchcraft. In the *Magnalia* he relates the freaks of a young girl whom he had taken into his house. In 1689 he published *Memorable Providences Relating to Witchcraft,* and three years later twenty executions for this crime took place in Salem. Mather assisted in the work, and wrote a full account in his *Wonders of the Invisible World* (1693). The excitement had not abated when the Boston merchant, Robert Calef, exposed the affair in his *More Wonders of the Invisible World* (1700). By Mather's agency this book was burnt at Harvard College. Long afterward he repeated the old stories, but he never recovered his former prestige. Yet he deserves credit for his courage in resisting public opinion when he introduced the practice of inoculation as a preventive of small-pox. His character has been vindicated in the biography by Barret Wendell.

Edwards.—In a border settlement of Massachusetts was produced the greatest work of Puritan metaphysics. Jonathan Edwards (1703-1758) was born at East Windsor, Connecticut, where his father was the first pastor. From childhood he was noted for piety and literary ability. At the age of twelve he discussed materialism with a friend. He graduated from Yale College at seventeen, then studied theology and began to preach in New York at nineteen. In 1726 he was ordained, and married Miss Sarah Pierrepont, a beautiful lady of equal clerical connection. Edwards became assistant to his grandfather in the pastorate at Northampton. His preaching was attended with a religious revival, which he reported in *A Narrative of Some Surprising Conversions* (1736). He went on to prepare a *Treatise on Religious Affections* (1740.) In the course of years he undertook to establish stricter rules with regard to admission to full communion. After long controversy and unhappy agitation he was dismissed by an ecclesiastical council in 1750. He retired at Stockbridge, where he was missionary to the Indians. Here, in the midst of cares and anxieties, he wrote his celebrated *Essay on the Freedom of the Will and Moral Agency* (1756). Able theologians and philosophers have acknowledged its argumentative power; some have attacked it vigorously; yet, in the main, its force remains unshaken. It is a central bulwark of Calvinistic philosophy. An almost immediate effect of its publication was an invitation to become president of Princeton College. He was installed in January, 1758. Soon after he was inoculated he was seized with a fever, and died in March. He was the most voluminous writer of his century, his works forming ten volumes. Though he had but a weak voice and disdained all arts of oratory, he was an effective preacher. His influence is clearly seen in the theological literature of New England for a full century.

Woolman. — Charles Lamb has advised his readers to "get the writings of John Woolman by heart, and love the early Quakers." Woolman (1720-1772) was born at Northampton, New Jersey, brought up in the Society of Friends, and early became a minister. After a trial of shopkeeping he became a tailor, but at various intervals he traveled through the country on religious errands and visited Indian settlements. In 1749 he married "a well-inclined damsel." His Society published a tract which he had prepared, called *Some Considerations on the Keeping of Negroes* (1753). It was one of the earliest anti-slavery arguments. Woolman's conscientious scruples in regard to fighting were tested during the French War. In 1772 he visited England, and there died of small-pox. *The Journal of his Life and Travels in the Service of the Gospel* is his principal work. It has been abridged and edited by Whittier. The unpretending narrative is touching in its quaintness.

Franklin.—A brief notice of Benjamin Franklin (1706-1790) may conclude our survey of Colonial Literature. He has been pronounced "our first man of letters," yet he never published anything under his own name except his newspaper. He was more a man of invention and public spirit than a man of letters. His activity reached through our next period, but much of his writing belongs to colonial times. He was born in Boston, the youngest son of a large family. He learned to set type, and contributed anonymously to his brother's newspaper. But he ran away to Philadelphia, and there worked diligently at his trade.

Franklin prospered in business and in seven years had a newspaper of his own. In *Poor Richard's Almanac,* which he conducted for twenty-five years, by pithy proverbs he taught the people the way to wealth. In 1741 he founded the first literary magazine in America. He stimulated his fellow-citizens to pave the streets, to start a fire company and to found the first hospital in America. His literary junto has grown into the American Philosophical Association, his circulating library has become the Philadelphia Library, his academy has grown to be the University of Pennsylvania. He was the most obedient servant of the public, and he shrewdly ruled his grateful master. He was keen in perception and sound in judgment, the personification of common sense. His writings had a marked effect upon public opinion. When General Braddock needed wagons for his army and could not get them, he was advised to appoint Franklin quartermaster. When this was done, Franklin's neatly worded letter brought the farmers rushing to supply them. He served in the Legislature, and he was sent to England as the agent of Pennsylvania. Wherever he went he found occasion to write a brief letter, which accomplished its purpose. Where had this runaway printer's apprentice learned to write? He tells us himself in his *Autobiography*. He studied and imitated the style of Addison's *Spectator*. But his own style is more homely and direct. It is less polished, but keener; it has the vigor and conciseness of Swift without his harshness. Franklin was the only member of the committee of the Continental Congress that made alterations in Jefferson's draft of the Declaration of Independence. "The burning page of Jefferson bears Franklin's calmer lines."

Franklin, at the age of seventy, went to France in the service of his country. In the midst of the most highly decorated court of Europe he appeared like an ancient philosopher returned to earth in modern dress. He charmed king and court by the simplicity of his attire, the wit and wisdom of his address. At a special fête before a crowded theatre, Voltaire, the sovereign of literature, embraced Franklin, the master of science. At the psychological moment the alliance of the two nations was effected. It was during his residence in France that Franklin wrote his most charming "bagatelles," as he called them. To the leisure of this period is also due his simple, straightforward *Autobiography*. It was published surreptitiously and incorrectly. Nearly a hundred years passed before the correct version appeared.

Franklin returned to America to assist in framing the Constitution of the nation and to be chosen president of Pennsylvania. He died full of years and honors. A Frenchman summed up his service to mankind in a Latin line—

Eripuit fulmen cœlo, sceptrumque tyrannis.

He snatched the lightning from heaven, and the sceptre from tyrants.

CHAPTER II.

The Revolutionary Period.

A. D. 1765—1790.

Preparation.—The Revolution was an unexpected sequel to the French and Indian War. Great Britain was heavily burdened by the expense of the conflict. Parliament, in looking around for new sources of revenue, decided that it had a right to tax the colonies. But the colonies had already contributed liberally with men and means for the war in America. Parliament imposed light taxes, first on stamps, afterward on tea. The leading men in the colonies had learned political wisdom in trying to manage their affairs and in resisting the arbitrary acts of royal and proprietary governors. They claimed the rights of free-born Englishmen that they should not be taxed when not represented in Parliament. The king and his ministry were amazed at the steadfast resistance of the Americans. The colonies had been brought into some degree of united action in the French War. They were thus prepared to make common cause against British injustice. Political discussions took place both in North and South. The brilliant oratory of Patrick Henry, John Adams and James Otis was followed by the able State papers of Dickinson and Jefferson.

Before independence was declared, Thomas Paine roused the people to patriotic action by his *Common Sense,* and afterward renewed their courage by his *Crisis*. During the struggle satires were directed against the Tories, and ballads ridiculed the British. Philip Freneau, patriot and poet, wrote for newspapers in various styles. When independence was attained a new government had to be established. The convention for this purpose succeeded far beyond their own expectations in framing the Constitution. Its principles were admirably explained in the *Federalist,* a series of essays by Hamilton, Madison and Jay. Their value as political essays has been recognized by all subsequent writers.

Dickinson.—No man was more actively employed in drawing up State papers in behalf of the colonies before the declaration of independence than John Dickinson (1732-1808). He was born in Maryland, but resided chiefly in Pennsylvania, though finally in Delaware. He was of Quaker descent, and studied law in London. In 1765, at the Stamp Act Congress in New York, he drafted the resolutions adopted. In 1768, under the name of "a Pennsylvania Farmer," he published *Letters to the Inhabitants of the British Colonies*. Their style is dignified and their argument cogent. They had influence in Great Britain as well as in America, but did not alter the course of events To Dickinson is due the phrase, "No taxation without representation." When he became a member of the first Continental Congress, in 1774, his services were needed to draw up the *Petition to the King,* the *Declaration to the Armies* and the *Address to the States*. Their vigorous defense of the rights of Americans convinced their friends but not their foes. The king's ministers pronounced the colonies in rebellion. In the next Congress Dickinson drew up a plan of confederation, but it was rejected as limiting the general government too much. He opposed the declaration of independence as premature until the colonies were better united and foreign assistance assured. When the war reached the Middle States he enlisted as a private, but was soon made a brigadier-general. He afterward resided alternately in Pennsylvania and Delaware. On behalf of Congress, in 1779, he wrote an *Address to the States,* calling for vigorous action. Under the signature Fabius he advocated the ratification of the Federal Constitution in 1787. Delaware was the first State to ratify the document, and Pennsylvania followed five days later. When war with France was threatened in 1797 a second series of letters signed Fabius urged forbearance toward our old ally. His political writings were collected and published in 1801. His style was commended by English and French statesmen.

Witherspoon.—Though a native of Scotland and minister of its Church, John Witherspoon (1722-1794) attained fame as president of Princeton College and signer of the Declaration of Independence. Before he left Scotland he had been prominent in church controversies, and had published three volumes of *Essays* (1764). He came to America on receiving a second call to Princeton in 1768. He said afterward that he "had become an American the moment he landed." When the struggle for independence began his influence was on that side. When the war closed his college he served in the New Jersey convention and helped to frame the State Constitution. Being sent to the Continental Congress, his first act was to sign the Declaration of Independence. He was active in Congress till 1782, and drew up many of its papers. His *Works* were collected in four volumes in 1801, and later editions have been issued.

Freneau.—The best poet of the Revolutionary period was Philip Freneau (1752-1832). He was of Huguenot descent, and was born in New York. During the war he was taken captive by the British and confined in a prison-ship. He was a fluent writer and after the war was constantly engaged in writing for newspapers. His poetry comprised hymns, satires, descriptive and patriotic pieces. Perhaps his best are *The Old Indian Burying Ground* and *The Wild Honeysuckle,* both showing love of nature and talent for description. Freneau was an ardent follower of Jefferson, and his excess of party spirit hurt his reputation. His poetry, scattered in newspapers, was not carefully collected or edited till 1904.

Trumbull.—A remarkable imitation of *Hudibras* was issued in 1776 bearing the name *McFingal.* It was written by John Trumbull (1750-1831) and was intended to ridicule Tories of Connecticut. The resemblance to *Hudibras* is chiefly in the short metre, clipped words and imperfect rhymes. The butt of the satire is a garrulous High-Church Scotch-American. The first canto describes a town-meeting held just after receiving news of the fight at Lexington. Honorius (who stands for John Adams) delivers a patriotic speech, which 'Squire McFingal interrupts. His argument shows self-interest and hope for reward. Honorius reviles Gage, and the Tories become boisterous. Finally the mob enters and breaks up the meeting. In the later part, added after the surrender of Cornwallis, McFingal is tarred and feathered and fastened to a liberty pole. He escapes to his cellar, where the Tories hold a council. McFingal in a prophetic strain tells the triumph and glory of America. But while he is speaking the approach of the Whigs is heard, and McFingal escapes through the cellar window.

Trumbull was born at Waterbury, Conn., and graduated at Yale College. He wrote serious poetry as well as satire. In 1775 he ridiculed General Gage's proclamation, and afterward used part of this burlesque in *McFingal.* Trumbull studied law with John Adams, rose to eminence in his profession and became a judge.

Hopkinson.—Another satirist of this period who also became a judge was Francis Hopkinson (1737-1791). He was born in Philadelphia and was the first graduate of the college which has become the University of Pennsylvania. He was small in size and a dilettante in accomplishments, yet active as a lawyer and a signer of the Declaration of Independence. In 1774 he published under a pseudonym *A Pretty Story,* describing the dispute between the masters of the Old Farm (England) and the settlers of the New Farm (America). During the war his ballad, *The Battle of the Kegs* (1778), ridiculed the alarm which the British troops in Philadelphia experienced when some kegs came floating down the Delaware. The troops were ordered out and the cannon trained on the hapless kegs. Still later Hopkinson used his talent in song on *The New Roof* to secure popular approval of the proposed Federal Constitution. When he signed the Declaration he was a delegate from New Jersey, as he resided then at Bordentown.

His son, Joseph Hopkinson (1770-1842), who was also a Federal judge, composed the national song *Hail Columbia* in 1798, at a time when war was threatened with France. It was intended to allay animosity between conflicting parties by uniting them in patriotic feeling.

Thomas Paine.—The English Thomas Paine (1737-1809), after giving a notable impulse to the

American Revolution, went to France to take part in its commotion, and narrowly escaped the guillotine. His notorious infidelity eclipsed his patriotic service. Paine was born at Thetford, England, the son of a Quaker. He was engaged in the excise service, and wrote such a clear description of the system that Franklin, then agent of the Pennsylvania colony, advised him to go to America as a better field for his talents. Paine, who was a radical republican, came to Philadelphia and was made an editor of the *Pennsylvania Magazine.* Early in 1776 he published the pamphlet *Common Sense,* which urged absolute independence from Great Britain. The arguments were put with such clearness and force as to produce immediate effect on public opinion. The Legislature of Pennsylvania voted a grant of £500 to the author. In the winter Paine published *The Crisis,* another stirring pamphlet, which Washington ordered to be read to each regiment in the army. Afterward Paine issued other numbers under the same title. He was made secretary of the Congressional committee on foreign affairs and, in 1779, clerk of the Pennsylvania Legislature. After peace was declared Congress voted to Paine $3,000, and the State of New York gave him a farm.

Having given some attention to mechanical inventions, Paine went to Europe to introduce them. In London, in reply to Burke's *Reflections on the French Revolution,* he issued *The Rights of Man* (1791). For this he was outlawed by the court of the King's Bench. In France he was welcomed and elected to the National Convention. But when he opposed the execution of Louis XVI he was expelled by the Jacobins. For a year he was confined in the Luxembourg prison, but finally was released by the efforts of the American Minister, James Monroe. In a public letter Paine abused President Washington for not having interfered on his behalf. Many of his former friends were alienated when he published *The Age of Reason* (1794), which he had written in prison. A second part was added a year later. Both contained offensive attacks on the Bible. Paine returned to the United States in 1800, but never recovered his popularity. He became intemperate and died in poverty in New York.

Besides his chief publications Paine wrote a variety of tracts and pamphlets on various subjects, local and temporary. His style was remarkably clear and pungent, but he sometimes descended to scurrility.

Hamilton.—From the opening of his political career to its lamentable end brilliancy and conservatism were remarkably combined in Alexander Hamilton (1757-1804). He was born on the island of Nevis, in the West Indies, of a Scotch father and French mother. At the age of twelve he was placed as a clerk in St. Croix, but at sixteen he entered King's College (now Columbia University) in New York. When the American people began to protest against the arbitrary acts of the British government, the loyalist Rev. Samuel Seabury (afterward first bishop of the American Church) published *Free Thoughts on the Proceedings of the Continental Congress.* The ardent young student replied anonymously with a *Full Vindication of Congress.* Another pamphlet by Seabury appeared as by "A Westchester Farmer," and Hamilton retorted with *The Farmer Refuted.* In March, 1776, Hamilton entered the patriot army and was made captain of artillery. After a year's service, Washington selected him as an aide and confidential secretary. Hamilton's proficiency in French, and his clear literary style, made his assistance valuable. In 1780 Hamilton married a daughter of General Philip Schuyler.

When American independence was achieved, the task remained to form a more perfect union of the States. Hamilton was a delegate to the Constitutional Convention which met in Philadelphia in 1787. Having seen the evils of the weak Confederation, he advocated a strong central government. When the Federal Constitution was submitted to the people of the several States for ratification, Hamilton, Madison and Jay published in a New York paper a series of essays in explanation and defense of the plan proposed. The series is known as *The Federalist.* Of its eighty-five papers Hamilton prepared fifty-nine, Jay five and Madison twenty-one. They are patriotic in spirit, profound in logic and brilliant in execution. They remain the most valuable interpretation of the Constitution.

When Washington was unanimously elected President in 1789, he called Hamilton to take charge of the treasury. In January, 1790, the new Secretary sent to Congress his *Report on the Public Credit,* which reduced the confused finances to order, provided for a funding system and taxes to meet it, and advised the assumption of the State debts incurred during the Revolution. This financial policy cemented the Union and established the credit of the nation. When the French revolution brought danger of war, Hamilton supported Washington's course of neutrality and defended it in the press under the signature "Pacificus." Strife arose in the Cabinet between Jefferson and Hamilton, and the former withdrew. In 1795 Hamilton also resigned and resumed the practice of law in

New York City. But his interest in Washington's administration did not cease. When Jay's treaty with Great Britain was in danger of defeat in the Senate, he defended it in a series of letters signed "Camillus." Hamilton had furnished drafts for several of Washington's Presidential messages, and he contributed toward the preparation of the memorable *Farewell Address.*

In the Federal party there was rivalry between John Adams and Hamilton for the leadership. Their dissensions were a potent cause for its defeat in 1800. When Jefferson and Aaron Burr had an equal number of votes for the Presidency, Hamilton, who distrusted Burr, secured Jefferson's election. Again in the contest for the governorship of New York, in 1804, Hamilton caused Burr's defeat. Burr then challenged him for slander, and Hamilton accepted. They met at Weehawken, opposite New York, on July 11, 1804. Hamilton fell mortally wounded at the first fire.

Foremost among the great political writers of America stands Alexander Hamilton. His foresight was keen, his ideas were comprehensive, his clear, forcible style carried conviction. His constructive genius helped to frame the noble Ship of State, to launch it for its proud destiny, to map out its future course. No grander eulogy can be pronounced on an administrator than was given to him by Daniel Webster: "He smote the rock of national resources, and abundant streams of revenue poured forth. He touched the dead corpse of public credit, and it sprung upon its feet."

CHAPTER III.

The National Period till the Civil War.

A. D. 1800—1865.

Philadelphia as the National Centre.—From 1774 to 1800 Philadelphia had been practically the capital of the United States. There the Continental Congress had regularly met; there the Declaration of Independence was signed; there the Federal Constitution was framed; there Washington and Adams had spent the greater part of their Presidential terms. That city, from its situation almost midway between the extremes of the thirteen original States, had been the most convenient meeting place for their delegates. It had been the resort of distinguished foreign visitors, who invariably gave it their tribute of praise.

But an absurd dread of the possibility of conflict between the national and State or local governments; a dread also of the excessive influence of a large State and densely populated city on the legislation for the whole country; an equally absurd fear of the distractions and luxuries of such a city interfering with the duties of Congress, and doubtless the remembrance that Philadelphia had been easily captured in the Revolutionary War, caused the framers of the Constitution to prescribe a Federal district, under the immediate control of the national authorities, as the seat of the new nation. By a political bargain this seat was fixed on the banks of the Potomac, where a full century was required to furnish a suitable habitation for the chosen servants of the people.

Philadelphia as a Literary Centre.—From its foundation Philadelphia had been the most cosmopolitan city in America. Swedes, Germans, French, Irish, Scotch, as well as English, had come willingly to the City of Brotherly Love. There they mingled in a harmony that astonished observant travelers. They entered upon a new united life, compared their various views and discussed great problems. The political stir which preceded and followed the Revolution gave abundant employment to the Philadelphia press. When a stable government was formed, and the Americans began to need books of their own composition and printing, Philadelphia publishers willingly risked their capital to meet the popular demand. It is true they did much reprinting of standard English works, but they were ready also to encourage native genius. Charles Brockden Brown was the first American novelist. Joseph Dennie, the editor of the *Portfolio,* was called the American Addison. Even authors residing in New England and New York had their books printed in Philadelphia. Some of Irving's books were published there, as was also Longfellow's *Poets and Poetry of Europe.*

Literary New York.—But when Philadelphia lost the prestige of being the national capital, New York began to develop the immense advantages of its splendid harbor. Wealth increased rapidly at the great port of entry. With wealth came opportunity to gratify intellectual cravings. New York furnished the most notable pioneers of national literature—Washington Irving and Fenimore Cooper. Irving began as a playful satirist of that city, and though he afterward made sketches of merry England and picturesque Spain, his mind ever turned fondly to his beloved Hudson. Cooper, from the lake region of the Empire State, sent forth the romance of the American forest. He had been an officer in the navy, and was thus qualified to depict the vicissitudes of the sailor's life. The *Knickerbocker Magazine* succeeded to the place once occupied by *Graham's* as the fosterer of budding genius. After a time *Putnam's* performed the same kindly office. Eventually, *Harper's Magazine,* which had been largely occupied with reprints of foreign authors, became more independent and truly American.

Literary Boston.—But in the meantime Boston was steadily advancing. Harvard College was an efficient promoter of literature. The *North American Review* was established as a native rival to the British quarterlies. The Unitarian movement had a distinct uplifting effect on American culture. Channing and Emerson, Longfellow and Lowell, elevated the minds and widened the outlook of their countrymen. Hawthorne devoted himself to the artistic delineation of New England life, sometimes exhibiting its romance, sometimes probing its mysteries. The anti-slavery agitation enlisted the services of literary men in Boston, and later the Civil War stimulated their patriotism. The *Atlantic Monthly,* edited by Lowell, maintained a high standard of literary excellence. Its critiques were the best and fairest which had yet appeared. To the *Atlantic* Longfellow, Emerson and Hawthorne contributed some of their best work. Dr. Holmes, who had already won reputation as a poet for class-days and similar occasions, increased his fame by *The Autocrat of the Breakfast Table.* Whittier, the Quaker poet and anti-slavery lyrist, became a regular contributor. In a powerful novel Mrs. Harriet Beecher Stowe, who had lived in Cincinnati, set forth the evils of slavery, which was effective in promoting its abolition. To the *Atlantic* she contributed milder stories of domestic life, usually in New England, but once from sunny Italy.

Southern Writers.—Poe, though born in Boston, belonged by training and disposition to Virginia; yet in his literary career he flitted between Philadelphia and New York. In his poems he was a wonderful metrical artist; in prose he wove strange plots and mysteries. More completely Southern, W. Gilmore Simms rivaled Cooper in delineating Indians, and preserved the romance of the Revolution. J. P. Kennedy also wrote a Southern novel of that period and sketched country life in Virginia. Augusta J. Evans (afterward Mrs. Wilson) wrote some impassioned novels with frequent literary allusions. But the South has done better work since the Civil War than before.

C. B. Brown.—The first American novelist and the first American that made literature a profession was Charles Brockden Brown (1771-1810). He was of weak physique, and his life was a constant struggle with ill health. His first publication was *Alcuin: A Dialogue on the Rights of Women.* Then he wrote some political pamphlets and biographical essays. He made three attempts to establish a monthly magazine, but without success. His *American Register,* which had been a department in one of them, was later made a semi-annual compilation. In fiction he was imitative, being strongly influenced by Mrs. Radcliffe and similar English writers. Their apparatus of mystery was transferred from European castles to American mansions. *Wieland* (1798) shows the influence of William Godwin. *Arthur Mervyn* gives a realistic description of the epidemic of yellow fever in Philadelphia in 1793. All of his stories are sombre. His style is clear and strong. Personally, he was gentle and amiable, and bore his illness bravely.

Barlow.—Strange was the literary and political career of Joel Barlow (1755-1812). Born in Connecticut, reared among orthodox Congregationalists, he graduated from Yale College, served as a chaplain in the Revolutionary army and versified psalms. He was one of "the Hartford wits," who satirized the Tories. But his ambition was to be an epic poet, and his grand *Vision of Columbus* (1787) was his first bid for fame. In 1788 he went to France as agent for an Ohio land company, but did not succeed in making sales. Mingling in the company of French journalists and politicians, he adopted their views. As a Girondist he contributed to the political literature of the day. Then going to London, in 1791, he joined the Constitutional Society, composed of republicans. Here, also, he wrote political pamphlets, the most important being *Advice to the Privileged Orders,* which Burke attacked and the British government proscribed. Back then to France hied Barlow, and sought election as a deputy to the National Convention. While visiting Savoy in this canvass his thoughts wandered to his Yankee home, and he wrote the mock-heroic poem, *Hasty Pudding* (1793). It is one of the best of its class, a pleasant description of a phase of American life.

During his eight years' residence, chiefly at Paris, Barlow managed to accumulate a fortune and indulge his propensity to literature. In 1805 he returned to America and established himself in a fine residence overlooking the city of Washington. His *Vision of Columbus* had now been enlarged into *The Columbiad* (1807), which was published in a handsome quarto. But the ponderous tome failed to arouse any enthusiasm; it was overloaded with politics and philosophy. In 1811 Barlow was sent as Minister to France, but found it difficult to transact any business, as Napoleon was absent on his Russian campaign. At last he was invited to meet the emperor at Wilna, in Poland. Thither he hastened, only to become involved in the disastrous retreat and fall a victim to cold and privation. Barlow's *Columbiad* remains unread; some of his hymns are sung in churches; but his *Hasty Pudding* preserves his name as a witty contributor to literature.

Washington Irving.—The first American to gain prominent distinction in the realm of pure literature was Washington Irving (1789-1859). Born in New York City, of Scotch descent, Irving, at the age of sixteen, began to study law. He was already inclined to literature, and soon contributed to his brother Peter's newspaper light essays on social topics signed Jonathan Oldstyle. In 1804, for the sake of his health, he went to France, and spent two years in traveling. On his return to New York he was admitted to the bar. But he found more congenial employment in describing the scenes and characters of New York for *Salmagundi,* a fortnightly periodical started by himself and Paulding. When Irving undertook to satirize an antiquarian sketch of his native city the work grew under his hand until it assumed the portentous size of *The History of New York from the Beginning of the World to the End of the Dutch Dynasty.* The work gravely professed to be written by Diedrich Knickerbocker, who was formally introduced to the public as a most learned Dutchman of the old school. The stupendous joke, with its load of learned allusions, delighted everybody except, perhaps, a few descendants of the Dutch settlers, who disliked to see their ancestors and their customs humorously satirized. In a second edition the well-disposed author made a kindly apology which retrieved the offense. And Knickerbocker has now become a name of honor, proudly displayed to the world.

But Philadelphia was still the literary centre, and thither Irving went to spend three years editing the *Analectic Magazine,* to which other New Yorkers contributed. After the peace of 1815 Irving, having formed a partnership with his brother, went to Liverpool. An opportunity was thus afforded to visit the picturesque parts of England. *The Sketch-Book by Geoffrey Crayon* was the fruit of these rambles. Although the sketches were intended to be published first in America, Murray, the London publisher, was induced by Sir Walter Scott to buy the copyright for £400. So great was the success of this venture that Murray was induced to pay more than twice or thrice the sum for Irving's next books, *Bracebridge Hall* and *Tales of a Traveler.* The *Sketch-Book* had mingled studies of English country life with fanciful American stories, chief among which was the legend of Rip Van Winkle. *Bracebridge Hall* exhibited a revival of the ancient customs of Christmas celebration. The *Tales of a Traveler* were drawn from various sources. Some English critics thought that Irving had overdone his praises of the good cheer of their land. But his humor, and even his satire, was kindly.

In 1825 Irving visited Spain and there found a splendid field for his genius, which he diligently improved. Noble work had recently been done by Navarrete in investigating the records of Columbus' discovery of America. These Irving undertook to transmit to English readers. The result was seen in his *Life and Voyages of Christopher Columbus,* followed by the *Voyages of the Companions of Columbus.* In these serious works Irving proved himself a diligent and painstaking historian. These works have stood the test of time, though much additional information has since been obtained. More romantic were his *Chronicles of the Conquest of Granada,* which professed to be a translation of a monkish record. The *Alhambra* consisted of pictures of Spain in the style of the *Sketch-Book.*

During the seventeen years spent in Europe Irving had acquired a competency and an international reputation. On his return to New York he was warmly welcomed. But he did not desist from his literary labors. He wrote *Astoria,* an account of Jacob Astor's settlement on the Pacific coast, contributed frequently to the *Knickerbocker Magazine* and published the *Crayon Miscellany.* In 1842 he was sent as American Minister to Spain, and on his return, four years later, settled at Sunnyside on the Hudson. Biographical works occupied the rest of his time, the *Life of Oliver Goldsmith, Mahomet and His Successors* (1850) and, finally, *The Life of Washington* (1859). The last, though a labor of love, proved to be the most toilsome of his life. But it is a noble monument, well proportioned, worthy both of its subject and its author.

During his residence at Sunnyside Irving was regarded as the foremost man of letters in America, but he never assumed the style of a sovereign. A favorite engraving, representing a group at Sunnyside, is entitled "Irving and his friends." He was a cheerful optimist, though he had suffered sore bereavement in the death of the lady to whom he was engaged when a young man. Henceforth he lived a bachelor; in his works a humorist, a patriot, a cautious historian. His style is clear and flexible; his humor genial; his pathos genuine and heartfelt. The firm impress of his generous character extends through all his works.

Cooper.—Out of the long list of Cooper's writings only a few volumes are worth reading. But these are sufficient to give him lasting fame as the revealer of the romance of the American forest and the foremost of sea-novelists. James Fenimore Cooper (1789-1851) was born at Burlington, New Jersey, but in infancy was taken to Cooperstown, which his father, Judge Cooper, had laid out in Central New York. The country was really a wilderness, inhabited only by Indians and pioneers. Amid the scenes of frontier life the boy was brought up by his father until he entered Yale College at the age of thirteen. Three years later he entered the navy as midshipman. Six years were spent in the service. Then he married and settled at Mamaroneck, New York. While reading an English novel to his wife, he happened to say that he could write a better one. Forthwith he undertook the task, but the book, called *Precaution,* a story of polite society, was a dismal failure. Still the resolute author persevered and found a better subject in the experiences of Washington's secret agents in the country around New York City during the Revolutionary War *The Spy* (1821), as the story was called, quickly became famous in Europe as well as America. Its strong feature was the delineation of Washington and of Harvey Birch, the spy. In *The Pioneers* (1823) Cooper treated the frontier life with which he was perfectly familiar. Then in *The Pilot* (1825) he turned to the sea life which he knew well. From these books sprang eventually two series, first the *Leather-stocking Tales,* in which Natty Bumppo is the chief personage, and, second, the sea stories. Of the former, portraying Indian life, *The Last of the Mohicans* (1826) is the best. It relates to the French and Indian War and, though having some strange improbabilities, is esteemed for its portrayal of character. After publishing his second sea story, *The Red Rover* (1827), Cooper went to Europe.

During his six years abroad Cooper had strange experiences. At first he was delighted to see his works widely circulated and translated. Then he was offended by harsh comments on America and its people. He sent to newspapers and serials letters and articles correcting misstatements, and excited a vigorous controversy. He composed novels on European themes, but these are of little value. On his return to New York he resumed his novel writing, and also published a *Naval History of the United States,* which provoked a lawsuit. He got into other controversies, and when he attacked New England and the Puritans he stirred a hornets' nest. Full of pride and highly sensitive, he wasted his time and energy in libel suits. In his last novel, *The Ways of the Hour,* he criticized the system of trial by jury. The total number of his novels is thirty-four.

Cooper's novels are often weak in plot and cumbered with detail. His style is rather formal and old-fashioned. He has been charged with idealizing the Indians, but his older contemporaries accepted the portraits as life-like. He seldom takes care to discriminate his characters by appropriate speech. Yet he gives verisimilitude to Natty Bumppo and Long Tom Coffin. In describing special incidents he is generally effective. He has preserved for later generations interesting characters and experiences which without him would have vanished forever.

Bryant.—*Thanatopsis,* one of the noblest poems in the English language, was published in the *North American Review* in 1817. It marks an era in American poetry. The author who thus bade fair to become the greatest American poet was William Cullen Bryant (1794-1878). He was the son of a physician of Pilgrim ancestry, and was born at Cummington, in western Massachusetts. He attended Williams College for two years, and then left to study law. For eight years he practised law at Plainfield and still wrote poetry at intervals. In 1821 he read before the Phi Beta Kappa Society at Harvard a long poem, *The Ages,* describing the progress of humanity. His first volume contained, besides *Thanatopsis* and *The Ages,* several short pieces of decided merit.

In 1825 Bryant went to New York, and for a year edited literary periodicals, inserting in their pages more fine poems. Then he became an editor of the *Evening Post,* with which he remained connected as editor and proprietor to the end of his long life. The incessant demands of a daily paper and the discussion of political affairs prevented him from dallying with the Muses. His aim was noble, to promote the cause of good government, and often he had to endure unpopularity. His paper opposed slavery and advocated free trade. It gave encouragement to art and literature. Gradually, success, financial as well as moral, rewarded his labors. In occasional vacations he made tours in Europe and the Orient, the Southern States and the West Indies. Some of these are recorded in his *Letters of a Traveler* (1850). In his old age Bryant was one of the most distinguished citizens of the metropolis, and his seventieth birthday was celebrated with extraordinary honors. Again, in 1876, his fellow-citizens presented to him a rich silver vase, commemorative of his life and works. His last public address was at the unveiling of a bust of Mazzini in Central Park. Bryant, as he obtained leisure, renewed his acquaintance with the ancient classics, and when seventy years old contributed to the *Atlantic Monthly* a translation in blank verse of a passage from Homer. Such was its excellence that Longfellow and Lowell joined in urging him to translate the whole *Iliad*. This was accomplished in 1869, and then the veteran was still able to translate the *Odyssey* (1871). These versions remain the noblest rendering of the works of the father of Greek poetry.

Bryant's editorial writing was always couched in pure and elegant English. He abhorred slang and exaggeration and would not resort to colloquialisms. His poetry was distinguished by simplicity, high finish and majestic repose. He never sought to express in passionate verse strong emotions or sufferings. His feeling, though deep, was seldom warmly expressed. His pensive poems show strong love of nature, true sympathy, wonderful outlook on the universe. Some of his early poems, as *Robert of Lincoln,* have a more joyful tone than is usual. His last poem, *The Flood of Years* (1877), repeated in the same solemn measure the deep meditation on the transitory existence of mankind that characterized *Thanatopsis,* written sixty-five years before.

Halleck.—In the Central Park at New York there is a memorial statue of Fitz-Green Halleck (1795-1867), who is hardly remembered among American poets. Yet there was a time when every schoolhouse rang with his stirring *Marco Bozzaris,* so fit for schoolboy declamation. Halleck was born at Guilford, Connecticut, and went to New York to be bookkeeper for Jacob Barker and John Jacob Astor. He had also a literary partnership with his friend Drake, under the name "Croaker & Co.," which contributed to the *Evening Post.* Halleck wrote a touching poem on Drake's death. *Fanny,* the longest of his poems, was a satire on New York society. His visit to Europe in 1822 gave occasion for two fine poems, *Burns* and *Alnwick Castle.* When Mr. Astor bequeathed him an annuity, Halleck retired to his native town.

Drake.—At the early age of twenty-five died Joseph Rodman Drake (1795-1820), who had displayed fine fancy in poetry. He had been left an orphan in childhood, and suffered from poverty. He studied medicine and married the daughter of a wealthy shipbuilder. His youthful friendship with Halleck led to their writing humorous poems called *The Croakers.* But Drake also wrote the exquisite poem of *The Culprit Fay,* which brings fairyland to the banks of the Hudson. More popular is the noble poem, *The American Flag.*

Paulding.—As a man of letters, James Kirke Paulding (1779-1860) is best remembered by his youthful partnership with Washington Irving, yet he wrote many books—novels, satires, poems and parodies. He was also long engaged in public service, helped his party with his pen, and was Secretary of the Navy under President Van Buren. Born in Dutchess county, New York, he received but little education. At the age of nineteen he went to New York City to enter a public office. In 1807 he joined with Irving in quizzing the town in *Salmagundi.* At the opening of the second war with Great Britain he issued *The Diverting History of John Bull and Brother Jonathan,* thus adding a chapter to Arbuthnot's story. His parody of Scott's *Lay of the Last Minstrel,* published anonymously, was sternly condemned by the *Quarterly.* His long poem, *The Backwoodsman* (1818), describing the fortunes of a family migrating from the Hudson to the Western wilderness, had more truth than poetry. In 1819 he added a second part to *Salmagundi,* but it had neither the sparkle nor the success of the former. Resenting the tone of British travelers in the United States, he issued *John Bull in America, or the New Munchausen.* His *Chronicle of the City of Gotham* (1830) pretended to be a translation of old Dutch legends of New Amsterdam. Better than this, and indeed his best production, is *The Dutchman's Fireside* (1831), a lively description of the manners of the Dutch settlers of New York. Next came *Westward, Ho!* (1832), a story relating chiefly to Kentucky. *The Old Continental* (1846) was a novel of the Revolution. Besides other stories and sketches, he published a strong defense of slavery and a comedy called *The Bucktails, or the Americans in England* (1847). The *Literary Life of James K. Paulding* (1867), published by his son, gives pleasant pictures of Paulding and his frolicsome associates. His old-fogy disposition is attested by his opposition, when Secretary of the Navy, to the introduction of steamships.

Kennedy. — Like Paulding, John Pendleton Kennedy (1795-1870) was a politician and officeholder, but on the opposite side, being a stout Whig. Born in Baltimore, he was admitted to the bar in 1816. He was a member of Congress for several terms and was Secretary of the Navy under President Fillmore. His *Swallow Barn* (1832) did for rural Virginia what Paulding had done for Dutch New York. *Horseshoe Robinson* (1835) is a lively tale of the Revolutionary War in the South, showing the conflict between Whigs and Tories. *Rob of the Bowl* (1838) is a tale of early colonial days in Maryland. During the Civil War Kennedy supported the cause of the Union in *Mr. Ambrose's Letters on the Rebellion,* which were collected in 1865. He wrote also a *Life of William Wirt* (1849), and made other contributions to history.

Mrs. L. M. Child (1802-1880).—The first New England novelist was Lydia Maria Francis, who afterward was married to David Lee Child. She was descended from one of the first settlers of Cambridge, Massachusetts. She was born at Melford, in that State, but spent her girlhood in Maine. She was but seventeen years of age when an article in the *North American Review* inspired her with the idea of writing a story about colonial times. It was called *Hobomok, an Indian Story* (1821), and introduced well-known historical characters. Her next story, *The Rebels, or Boston Before the Revolution* (1825), contained a patriotic speech by James Otis and a sermon by Whitefield, both imaginary. Miss Francis became a teacher and published the first monthly magazine for children. After her marriage she edited books and magazines for women and children, wrote biographies of distinguished women, and compiled a *History of the Condition of Women in all Ages* (1845). Her most elaborate romance, *Philothea* (1835), related the story of Pericles and Aspasia. From the start of the anti-slavery agitation both Mr. and Mrs. Child were active in it. The first book published in that cause was her *Appeal for That Class of Americans Called Africans* (1833). It advocated the immediate emancipation of the negroes. When the American Anti-Slavery Society established a weekly paper in New York City in 1840, Mrs. Child was the editor, and her husband assisted. In 1844 they retired to Wayland, Massachusetts, where Mrs. Child wrote many books for children. Her ideas about religion had become very liberal, as was shown in a large work, *The Progress of Religious Ideas Through Successive Ages* (1845), which was the product of much labor but often inaccurate. Her anti-slavery writings, though seemingly disregarded for a time, had ultimate effect on public opinion in the North. At the close of the war she prepared *The Freedman's Book,* to assist in preparing the negroes for higher duties. Her last work was *Aspirations of the World* (1878).

C. M. Sedgwick.—The literary career of Miss Catherine Maria Sedgwick (1789-1867) ran parallel to that of Mrs. Child, but their religious views were widely different. Miss Sedgwick was the daughter of the distinguished Federalist, Hon. Theodore Sedgwick, who was a judge of the Supreme Court of Massachusetts. Born at Stockbridge, she was well educated. Having begun to write a religious tract, she found it expand under her hands into a long story. When published, under the title *A New England Tale* (1822), it was well received by the public. Her next story, *Redwood* (1824), was not only successful at home but was translated into several European languages. Being thus encouraged, she wrote stories on American subjects, *Hope Lestie, or Early Times in America* (1827), in which she utilized the scenery and traditions of her native place; *Clarence, a Tale of Our Own Times* (1830), and *The Linwoods* (1835), a romance of the Revolution. These historical tales were evidently inspired by the example and success of Scott and Cooper, though lacking the force of these great models. Afterward, Miss Sedgwick wrote a series of moral tales for children in the style of Miss Edgeworth, besides stories cultivating home sentiment.

Channing.—In the eighteenth century there was in New England a gradual reaction against the Calvinism of the Puritan settlers, whose theology had been formulated by the Westminster Assembly. At the beginning of the nineteenth a new influence came in, partly from British and partly from German sources. What had been a Liberal movement now became Unitarian under the leadership of the pure and eloquent William Ellery Channing (1780-1842). Born at Newport, Rhode Island, he was educated at Harvard, where he was distinguished for versatility of talent. For some months he was a tutor in Richmond, Virginia, but he returned to Newport and studied theology with Dr. Samuel Hopkins and others. In 1802 he began to preach, and in the next year was ordained pastor of the Federal Street Church, Boston. Small in person and of delicate physique, he was earnest and courageous. His eloquence and spiritual energy soon drew general attention. After he succeeded to the full charge of his church he became the leader of the liberal party in his denomination. He was active in all moral and philanthropic enterprises. He advocated temperance, public education, missions, Bible distribution and prison reform. He opposed war and slavery.

Channing's departure from orthodox theology was especially marked, in 1819, in a sermon preached in Baltimore. His party was henceforth known as Unitarians. With all their reverence for Jesus as the founder of Christianity they did not accept the doctrine of the Trinity. They rejected also the current view of human depravity and insisted on the inherent dignity of human nature. The ensuing controversy profoundly agitated all the churches of New England, and produced further movements affecting literature and politics. By purity of character and winning oratory Channing gained a remarkable influence over the rising generation. His best-known essays are the *Moral Argument Against Calvinism, The Character and Writings of John Milton, Napoleon Bonaparte, Fénélon, Self-Culture, The Elevation of the Laboring Classes.* He had preached against slavery for some years before he advocated political action in regard to it. His work on *Slavery* (1841) had wide circulation. In the midst of all the agitation his teaching produced he preserved calmness and candor, and maintained a hopeful view of human progress.

Emerson.—The intellectual movement in New England in the first third of the nineteenth century carried some thinkers beyond Unitarianism. The new German philosophy made theological systems too narrow and called for a reconstruction of the universe of thought. This new method of viewing the world received the name Transcendentalism. Its foremost representative was Ralph Waldo Emerson (1803-1882). Descended from eight generations of preachers, he was destined for the pulpit. His father was also editor of the *Monthly Anthology,* which diffused a taste for general literature. Ralph, born in Boston and graduating from Harvard, studied theology with Dr. Channing. He became assistant to Dr. Henry Ware and afterward succeeded to the entire charge of the Second Church, Boston. His preaching was on the lines of Channing, inculcating higher morality. Having come to regard communion as purely spiritual, he declined to dispense the Lord's Supper, and in 1832 resigned his charge, but he continued to preach for some years more.

His wife having died, Emerson went to Europe. After traveling in France and Italy, he passed through England and visited Carlyle in his remote abode at Craigenpottock. The two thinkers formed a remarkable friendship, which was maintained by correspondence through their lives. Emerson induced a Boston publisher to issue Carlyle's early books, and sent him compensation. In 1835 Emerson married Lilian Jackson and took up his residence in Concord. Henceforth his chief support was derived from lecturing and, later, from the books which embodied the lectures. He invested the platform of the lyceum with charm and social influence. His deliverances were oracular statements of his thoughts on the most important subjects. His first book, *Nature* (1836), set forth his transcendantal views of man and the universe. In the same year, for the celebration of the anniversary of the Concord fight of April 19, 1776, he wrote the hymn which helps to perpetuate its fame. His address at Harvard, in 1837, on *The American Scholar* was an inspiring call to higher aims in education. In the next year a similar address in the Divinity School on *The Christian Teacher* deeply stirred the Unitarian party. A controversy ensued in which Emerson took no part. Such self-restraint remained his habit throughout life. His *Essays* (1841) repeated and extended the views he had set forth in *Nature,* and were received with wider favor.

In 1844 several of Emerson's friends formed a communistic experiment at Brook Farm, but he, with more practical wisdom, held aloof. Yet he was an editor of *The Dial,* which they published. Emerson was active in the anti-slavery movement without going to the extreme of many of the agitators. His second visit to England in 1847 gave a fresh impulse to his mind. After his return he lectured on *Representative Men,* taking Plato, Shakespeare, Napoleon, Swedenborg and Goethe as his examples. This work forms an admirable contrast with that of Carlyle on *Heroes and Hero-Worship,* and illustrates the difference between the two writers, who yet highly esteemed each other. The lectures, dealing with concrete personalities, increased Emerson's hold on the public. Still more was this the effect of his lectures on *English Traits* (1856), which showed his keen insight into the condition and tendencies of a mighty people.

In 1857 a few of Emerson's literary friends formed in his parlor a plan for a new periodical to which they should regularly contribute. In the group were Longfellow, Lowell and Holmes, of whom Lowell was chosen to be editor. Such was the origin of the *Atlantic Monthly,* a potent factor in New England literature. In this new medium of access to the public Emerson used both verse and prose of high order. The poems were collected in *May Day* (1867). The essays form the substance of his books, *The Conduct of Life* (1860), *Society and Solitude* (1864) and *Letters and Social Aims* (1876). From the poems which he had written at various times Emerson made a collection in 1876. He also edited a selection of poetry by various authors in *Parnassus* (1874). In 1872 Emerson again went to Europe, bade farewell to Carlyle and traveled on the continent. In the latter part of his life his memory failed and his mind grew feeble, but he was carefully tended by his family and friends. He had projected a

"Natural History of the Intellect," in which much of his published writings was to be incorporated, but the plan was never realized. Since his death his works have been carefully edited, biographies have been written by Holmes, Sanborn and Cabot, and numerous treatises on his genius and influence have appeared.

Emerson is generally regarded as a philosopher, but he never formulated a system; in fact, his mind was not favorably disposed toward systems of any kind. But he taught a method of viewing life and the universe. He shared the pantheism which appears in Wordsworth's poetry. He regarded Nature, in its largest acceptation, as the manifestation of the Divinity, and conduct as the proper aim of man's life. Emerson spoke of himself as a poet, though not a great one. He had indeed the poet's view and inspiration, but not full ability of expression. Hence, his utterances, both in verse and prose, were brief and abrupt, often highly oracular and sometimes enigmatic. Matthew Arnold declared "Emerson's essays are the most important work done in prose" in the nineteenth century. He also pronounced Emerson not essentially a poet nor a philosopher, but a seer. He has affected the higher thought of the American people more than any other writer. Dean Stanley, after his visit to the United States, said he had heard many sermons, but it was always Emerson that spoke from the pulpit. In the principal cities the hundredth anniversary of Emerson's birth was celebrated, and speakers of all classes and forms of thought united in paying tribute to him as the inspirer of a higher and purer spiritual and intellectual independence.

THE RHODORA.

(On being asked, Whence is the flower?)

In May, when sea-winds pierced our solitudes,
I found the fresh Rhodora in the woods,
Spreading its leafless blooms in a damp nook,
To please the desert and the sluggish brook
The purple petals, fallen in the pool,
Made the black water with their beauty gay;
Here might the red-bird come his plumes to cool,
And court the flower that cheapens his array.
Rhodora! if the sages ask thee why
This charm is wasted on the earth and sky,
Tell them, dear, that if eyes were made for seeing,
Then Beauty is its own excuse for being:
Why thou wert there, O rival of the rose,
I never thought to ask, I never knew:
But, in my simple ignorance, suppose
The self-same power that brought me there brought
you.

CONCORD HYMN.

(Sung at the completion of the Concord Monument, April 19, 1836.)

By the rude bridge that arched the flood,
Their flag to April's breeze unfurled,
Here once the embattled farmers stood,
And fired the shot heard round the world.

The foe long since in silence slept;
Alike the conqueror silent sleeps;
And time the ruined bridge has swept
Down the dark stream which seaward creeps.

On this green bank, by this soft stream,
We set to-day a votive stone;
That memory may their deed redeem,
When, like our sires, our sons are gone.

Spirit, that made those heroes dare
To die, and leave their children free,
Bid time and nature gently spare
The shaft we raise to them and thee.

Thoreau.—The most singular disciple of Emerson was Henry David Thoreau (1817-1862). Born at Concord, the son of a farmer, he was educated at Harvard and for a time taught school. But he devoted himself to plain living and high thinking. In 1845 he built himself a hut on the shore of Walden Pond and entered into the closest communion with wild nature. His observations were gathered in *Walden, or Life in the Woods* (1854). He was a pantheist in religion and a cosmopolite in politics. He reduced his expenses to the lowest possible fraction of a cent, duly recorded in his book. He would pay no taxes and was, therefore, imprisoned till released on Emerson's paying them for him. But he published several books, and left journals to fill up several more. Some were furnished by his travels, always on foot. Among them are *Excursions, The Maine Woods, Cape Cod, A Yankee in Canada, Summer, Winter, Autumn.*

Poe.—Unique among the poets and prose writers of America, Edgar Allan Poe (1809-1849) still remains. The son of actors, he possessed a highly sensitive nature and wonderful command of sentiment and language, but showed little regard for truth. Born in Boston, he lost his parents in infancy, but was adopted and generously cared for by John Allan, a merchant of Richmond. He went to the University of Virginia, but wasted his time in gambling. Unwilling to be a clerk in Mr. Allan's counting-room, Poe went to Boston, where he published *Tamerlane and Other Poems* (1827). Then he enlisted in the army as a private, but in 1830 became a cadet at West Point Military Academy, where he remained a year. In the meantime he had published more poems at Baltimore and

New York, but he sought in vain for literary employment. In 1833 a prize of $100 was offered by a Baltimore newspaper and awarded to his tale, *A Manuscript Found in a Bottle.* At the suggestion of J. P. Kennedy he was made editor of the *Southern Literary Messenger* at Richmond and became noted by his weird tales and trenchant criticisms, but received little pay.

In 1836 he married his cousin, Virginia Clemm, then but fourteen years old, and soon afterward went first to New York and then to Philadelphia, where he wrote and compiled for a scanty subsistence. His *Tales of the Grotesque and Arabesque* (1839) brought him little but the copyright. For a year he assisted in editing Burton's *Gentleman's Magazine,* and when it became *Graham's Magazine* was made chief editor. By his tale, *The Gold Bug,* he won another $100 prize. His *Murder in the Rue Morgue* has been imitated in many detective stories. Translated into French it started Poe's popularity in France, which soon extended to his poems and has steadily increased.

But Poe soon lost his editorship by his irregular habits, and was reduced to worse poverty. He went back to New York and there published *The Raven* in the *Whig Review.* He drifted from one newspaper to another and formed various schemes for publishing. To *Godey's Lady's Book* he contributed a series on *The Literati of New York.* His wife died in 1847, and he was prostrated with serious illness. While still feeble he went to Richmond and made arrangements for marriage with a widow. But overcome in a mysterious manner, he died in a hospital at Baltimore.

Poe's morbid vanity led him to quarrel with those who wished him well. His criticisms professed to be founded on definite principles, but were sometimes spiteful. His tales were singularly ingenious and highly wrought, but do not touch the heart. They treat of mysterious crimes, strange retribution, fantastic discoveries and marvelous inventions. In these extravaganzas there can be detected a skepticism approaching to sardonic humor. But he had no true humor, and when he strove to be amusing he failed wretchedly. His poems are impressive with musical charm and unworldly beauty. He has given an analysis of his *Raven* which cannot be accepted as an explanation of its composition. Yet, throughout his poetry art prevails rather than inspiration.

TO HELEN.

Helen, thy beauty is to me
  Like those Nicean barks of yore,
That gently, o'er a perfumed sea,
  The weary, wayworn wanderer bore
  To his own native shore.

On desperate seas long wont to roam,
  Thy hyacinth hair, thy classic face,
Thy Naiad airs have brought me home
  To the glory that was Greece
And the grandeur that was Rome.

Lo! in yon brilliant window-niche
  How statue-like I see thee stand,
  The agate lamp within thy hand!
Ah! Psyche, from the regions which
  Are Holy Land!

TO ONE IN PARADISE.

Thou wast that all to me, love,
  For which my soul did pine:
A green isle in the sea, love,
  A fountain and a shrine
All wreathed with fairy fruits and flowers,
  And all the flowers were mine.

Ah, dream too bright to last!
  Ah, starry hope! that did'st arise
But to be overcast!
  A voice from out the future cries
On! on! But o'er the past
  (Dim gulf!) my spirit hovering lies,
Mute, motionless, aghast!

For, alas! alas! with me
  The light of life is o'er.
  "No more—no more—no more—"
(Such language holds the solemn sea
  To the sands upon the shore)
Shall bloom the thunder-blasted tree,
  Or the stricken eagle soar!

And all my days are trances,
  And all my nightly dreams
Are where thy dark eye glances
  And where thy footstep gleams—
In what ethereal dances,
  By what eternal streams!

Willis.—Almost forgotten is a poet of this period who for several years was more popular than Longfellow. Nathaniel Parker Willis (1806-1867), descended from a line of printers and newspaper publishers, was born at Portland, Maine. Before he graduated from Yale College, in 1827, he had published a series of Scripture narrative poems which were highly praised. He edited, at Boston, two volumes of *Annuals,* and founded a magazine which was afterward merged in the New York *Mirror.* This weekly paper, under the management of George P. Morris and Willis, became the chief organ of society and literature. In 1831

Willis went abroad and traveled extensively on the Continent, still writing letters for his paper. In 1837 he settled near Owego, New York, and till the death of his wife, in 1844, lived in grand style. In 1840 Morris and Willis established the *Home Journal,* and continued to edit it till their deaths. Willis wrote fluently in both prose and verse. Among his early secular poems *The Belfry Pigeon* and *Parrhasius* were most esteemed. Afterward he gave up the sentimental manner which was characteristic of his *Annuals,* and treated the same subjects with flippancy. He was noted for his elegant manners and dressed in the extreme of the fashion. His writings attracted and charmed the fashionable world. His *Pencillings by the Way* and other prose sketches of travels are pleasant reading, but too much of his poetry was written hastily and carelessly.

Longfellow.—No American poet is better loved by his countrymen or by the world at large than Henry Wadsworth Longfellow (1807-1882). He has treated the common experiences of life with such tender sympathy, with such abiding grace, that men and women cherish his poems. From remote countries and distant ages he has brought precious stores and invested them with the same endearing charm. Throughout his long life he showed the same dignified courtesy that shines through his poems.

Longfellow was born in Portland, Maine, then a district of Massachusetts. He was of Pilgrim descent, and in his poems delighted to honor his ancestry. He was educated at Bowdoin College, and there held the professorship of modern languages from 1829 to 1835. But before entering on his work there he had spent two years in Europe. From Bowdoin he was called to a similar professorship at Harvard, and then made a second visit to Europe. After discharging his professorial duties acceptably for seventeen years he resigned. Thenceforth he lived in Cambridge, the poet laureate of the American people. He was twice married—in 1831 and again in 1843. The accidental death of his second wife by burning, in 1861, was the greatest affliction of his life. He had early contributed to the *North American Review,* and in 1833 published an essay on *The Moral and Devotional Poetry of Spain,* with translations of Lope de Vega's sonnets. His prose works, *Outre-Mer* (1835) and *Hyperion* (1839), have lost such popularity as they once had. But with the *Voices of the Night* (1839) began his beautiful expression of the feelings of the heart. It contained *The Psalm of Life, The Reaper and the Flowers, Woods in Winter.* He always avoided strife, but in 1842 his moral nature was stirred to issue *Poems on Slavery,* dedicated to Channing. A collection of translations, partly selected from other authors, with introductory essays and biographical sketches, was published in 1846 under the title *Poets and Poetry of Europe.* About the same time appeared the dramatic poem, *The Spanish Student,* and *The Belfry of Bruges.*

Still more notable is the beautiful narrative poem, *Evangeline* (1847), always the author's favorite and dear to the public. It is the most successful English poem in dactylic hexameters. The deeply pathetic story, though partly founded on fact, appears to be an artistic creation. Two Acadian lovers, separated by the edict of exile, wander through the American colonies seeking each other for years. Yet they sometimes pass without knowing the fact. At last when Gabriel, worn out, lies dying in the hospital at Philadelphia, Evangeline, who for his sake had dedicated herself to the care of the suffering, finds and ministers to him. Soon after the publication of *Evangeline* Longfellow sent out his grand ode, *The Building of the Ship,* evidently an adaptation of Schiller's *Song of the Bell* to national feeling, and gratefully cherished by the American people.

In 1855, after the publication of some more volumes, Longfellow took up the myths of the American Indians, and attempted to make "an Indian Edda." The result was *The Song of Hiawatha,* which uses a rhymeless trochaic metre, adapted from the *Kalevala,* a simlar series of narratives recently collected among the peasantry of Finland. The stories poetized in *Hiawatha* had been gathered by Schoolcraft in his researches among the Indians near Lake Superior. Wild animals and supernatural beings take part as personages in the story. Hiawatha himself is a noble idealization of the Indian, and Minnehaha a beautiful example of womanhood. The canto describing the famine is rendered doubly impressive by her death.

In *The Courtship of Miles Standish* (1858) Longfellow utilized a charming legend of his own ancestry, showing how the mild clerk, John Alden, won the prize to which the doughty captain had aspired. In his *Tales of a Wayside Inn* (1863) he uses as a framework the meeting of some of his friends at an old hostelry at Sudbury, Massachusetts. Each narrator is fittingly described, and tells a tale appropriate to his character. The entire result is charmingly artistic.

Longfellow had, in 1851, published an English version of the mediæval *Golden Legend.* To this he joined, later, *The Divine Tragedy,* or story of Christ, and the *New England Tragedies,* a new presentation of the religious persecutions which form a foul blot on New England history. The trilogy bears the name *Christus*. It was intended to exhibit the slow progress and gross errors of humanity in accepting the divine revelation.

As early as 1842 Longfellow lectured on Dante, and illustrated his discourses by translations from the Italian. Steadily he added to these in the intervals of other occupations, and at last, in the time of his great sorrow, completed his version of the great mediæval poem, *The Divina Commedia*. He aimed to reproduce the exact effect of the original as far as difference of the two languages would permit. His translation is the most perfect rendering in English. The sonnets prefixed to each part are admirable tributes.

In *The Masque of Pandora* (1875), as in some previous works, Longfellow adopted the dramatic form, but he never had the real dramatic spirit which brings the actions of a diversified group into unity. Yet all his dramatic poems have beautiful passages. *The Hanging of the Crane* (1874) tells the story of the household from the wedding till the children grow up and depart, leaving the aged parents again alone. At the fiftieth anniversary of his graduation at Bowdoin, Longfellow presented his affectionate tribute to his Alma Mater in *Morituri Salutamus*. His last poem was *Hermes Trismegistus*.

From 1836 Longfellow had lived in the Craigie house at Cambridge, in an environment admirably suited to his genius. His European reputation was hardly inferior to that which he enjoyed in his own land. His life is excellently displayed in his letters and biography published by his brother.

Longfellow was refined in taste, in dress and personal associations. All his friends were literary or academic. Though possessing high culture, he never allowed it to overshadow the primary range of feeling. From his stores of learning he brought new themes and abundant illustrations to exemplify and adorn the calm joys and natural afflictions of common life. Thus his high genius and exquisite taste were proved. In return the common people heard him gladly and took up his words as their own. Wherever the English language is spoken his verses have found lodgment in the popular memory. Longfellow never attempted to depict the elemental passions, the storms of the spirit. He not only preferred the serene air and glad sunshine, but he confined himself to it save when he looked forth on the still beauty of night. Though he brought many treasures from foreign sources, his work would have been incomplete had he not embodied in his verse something distinctively American. This duty was performed not only in New England ballads, tales and dramas, but in the more difficult task of transferring the myths of the American aborigines into a form which should be artistic and yet not destroy the primitive spirit.

THE LAUNCHING OF THE SHIP.

(From *The Building of the Ship.*)

All is finished! and at length
Has come the bridal day
Of beauty and of strength.
To-day the vessel shall be launched!
With fleecy clouds the sky is blanched,
And o'er the bay,
Slowly, in all his splendors dight,
The great sun rises to behold the sight.
The ocean old,
Centuries old,
Strong as youth, and as uncontrolled,
Paces restless to and fro,
Up and down the sands of gold.
His beating heart is not at rest;
And far and wide,
With ceaseless flow,
His beard of snow
Heaves with the heaving of his breast.
He waits impatient for his bride.
There she stands,
With her foot upon the sands,
Decked with flags and streamers gay,
In honor of her marriage day,
Her snow-white signals fluttering, blending
Round her like a veil descending,
Ready to be
The bride of the gray old sea.

* * * * * * * * * *

Then the Master,
With a gesture of command,
Waved his hand;
And at the word,
Loud and sudden there was heard,
All around them and below,
The sound of hammers, blow on blow,
Knocking away the shores and spurs.
And see! she stirs!
She starts—she moves—she seems to feel
The thrill of life along her keel,
And, spurning with her foot the ground,
With one exulting, joyous bound,
She leaps into the ocean's arms!

And lo! from the assembled crowd
There rose a shout, prolonged and loud,
That to the ocean seemed to say,
"Take her, O bridegroom, old and gray,
Take her to thy protecting arms,
With all her youth and all her charms!"

How beautiful she is! How fair
She lies within those arms, that press
Her form with many a soft caress
Of tenderness and watchful care!
Sail forth into the sea, O ship!
Through wind and wave, right onward steer!
The moistened eye, the trembling lip,
Are not the signs of doubt or fear.

Sail forth into the sea of life,
O gentle, loving, trusting wife,
And safe from all adversity
Upon the bosom of that sea
Thy comings and thy goings be!
For gentleness and love and trust
Prevail o'er angry wave and gust;
And in the wreck of noble lives
Something immortal still survives!

Thou, too, sail on, O Ship of State!
Sail on, O Union, strong and great!
Humanity with all its fears,
With all the hopes of future years,
Is hanging breathless on thy fate!
We know what Master laid thy keel,
What Workmen wrought its ribs of steel,
Who made each mast, and sail, and rope,
What anvils rang, what hammers beat,
In what a forge and what a heat
Were shaped the anchors of thy hope!
Fear not each sudden sound and shock,
'Tis of the wave and not the rock;
'Tis but the flapping of the sail,
And not a rent made by the gale!
In spite of rock and tempest's roar,
In spite of false lights on the shore,
Sail on, nor fear to breast the sea!
Our hearts, our hopes, are all with thee,
Our hearts, our hopes, our prayers, our tears,
Our faith triumphant o'er our fears,
Are all with thee—are all with thee!

THE TWO ANGELS.

(On the same night Lowell's wife died and a daughter was born to Longfellow.)

Two angels, one of Life and one of Death,
  Passed o'er our village as the morning broke;
The dawn was on their faces, and beneath,
  The sombre houses hearsed with plumes of smoke.

Their attitude and aspect were the same,
  Alike their features and their robes of white;
But one was crowned with amaranth, as with flame,
  And one with asphodels, like flakes of light.

I saw them pause on their celestial way;
  Then said I, with deep fear and doubt oppressed,
"Beat not so loud, my heart, lest thou betray
  The place where thy beloved are at rest!"

And he who wore the crown of asphodels,
  Descending, at my door began to knock,
And my soul sank within me, as in wells
  The waters sink before an earthquake's shock.

I recognized the nameless agony,
  The terror and the tremor and the pain,
That oft before had filled or haunted me,
  And now returned with threefold strength again.

The door I opened to my heavenly guest,
  And listened, for I thought I heard God's voice;
And, knowing whatsoe'er He sent was best,
  Dared neither to lament nor to rejoice.

Then with a smile that filled the house with light,
  "My errand is not Death, but Life," he said;
And ere I answered, passing out of sight,
  On his celestial embassy he sped.

'Twas at thy door, O friend! and not at mine,
  The angel with the amaranthine wreath,
Pausing, descended, and with voice divine,
  Whispered a word that had a sound like Death.

Then fell upon the house a sudden gloom,
  A shadow on those features fair and thin;
And softly, from that hushed and darkened room,
  Two angels issued, where but one went in.

All is of God! If He but wave His hand,
  The mists collect, the rain falls thick and loud,
Till, with a smile of light on sea and land,
  Lo! He looks back from the departing cloud.

Angels of Life and Death alike are His;
  Without His leave they pass no threshold o'er;
Who, then, would wish or dare, believing this,
  Against His messengers to shut the door?

Lowell.—The great breadth of his work and high quality of his performance entitle Lowell to be called the best representative of America in literature. He succeeded equally well in prose and verse, in description and satire, in noble allegory and humorous dialect, in lofty ode and searching criticism. James Russell Lowell (1819-1891) was born at Cambridge, Massachusetts, of a family long prominent in public affairs. The son of Rev. Charles Lowell, he graduated from Harvard in 1838 and studied law, but hardly practised. His first book, *A Year's Life,* was composed of poems inspired by his affection for Maria White, who became his wife. She was deeply interested in the anti-slavery movement, and led him to give time and labor to its advocacy.

The timid subserviency of New England politicians in approving the war with Mexico roused his indignation, which found an unexpected outlet. In homely Yankee dialect these leaders were pilloried. These *Biglow Papers* were begun in 1846 and continued through the war. A second series was published during the greater Civil War, but seemed less appropriate. No American writer has ever excelled Lowell in mastery of the Yankee dialect and insight into the workings of the Yankee mind.

But Lowell did not confine himself to anti-slavery and political work. That was his play. His work was on nobler themes. *The Vision of Sir Launfal* (1845) was a story of the quest of the Holy Grail, which embodied in beautiful poetry a noble lesson. The anonymous *Fable for Critics* was a playful criticism on the authors of the day, including himself; its title page was in rhyme.

In 1851 Lowell, with his second wife, went to Italy, where he studied art and literature. In 1855 he succeeded Longfellow as professor of modern languages at Harvard. Two years later he joined in founding the *Atlantic Monthly,* of which he was the first editor. Later he became also editor of the *North American Review.* The criticisms and miscellaneous essays published in these periodicals were of the highest order. They afterward formed the contents of *Among My Books* and *My Study Windows.* During the Civil War the *Atlantic* steadily supported the administration of President Lincoln. After its close the authorities of Harvard decided to commemorate the graduates who had given their lives in defense of the Union. Lowell was invited to recite the poem, and did so in the grand *Commemoration Ode,* which is the noblest poem inspired by the war. Having reached this lofty height Lowell felt himself bound to preserve his dignity. *The Cathedral* (1870) is a worthy second to the former ode.

In 1877 President Hayes commissioned Lowell as American Minister to Spain, and later he was transferred to England. In both countries he was the recipient of high honors. In 1885 he returned to Cambridge and there resided until his death. Of the books published in this interval, all but one consisted of prose essays.

Lowell was more active in public affairs than Longfellow. While he was eminently a scholar of both ancient and modern lore, he was keenly interested in the movements of his own day. Yet his name is not as familiar as his brother poet's, and his works are less widely read. They require more learning and more effort than the majority of people can give. But when studied and appreciated they reward the reader with choice treasures. His prose essays are less dogmatic than those of Matthew Arnold, but they show a man of equal ability and less arrogance. Even as a humorist Lowell's appeal is to a cultivated class. The man whose dialect is so exactly copied feels that the laugh is directed at him as well as some imaginary opponent. But on the cultured youth of his country Lowell conferred an inestimable boon in giving them a lofty example and teaching them to preserve their self-respect.

THE COURTIN'.

Zekle crep' up, quite unbeknown,
An' peeked in thru the winder,
An' there sot Huldy all alone,
'Ith no one nigh to hender.

Agin the chimbly crooknecks hung,
An' in amongst 'em rusted
The ole queen's arm thet Gran'ther Young
Fetched back from Concord busted.

The wannut logs shot sparkles out
Toward the pootiest, bless her!
An' leetle fires danced all about
The chiny on the dresser.

The very room, coz she wuz in,
Looked warm from floor to ceilin',
An' she looked full ez rosy agin
Ez th' apples she wuz peelin'.

She heerd a foot an' knowed it, tu,
Araspin' on the scraper;
All ways to once her feelin's flew
Like sparks in burnt-up paper.

He kin' o' l'itered on the mat,
Some doubtfle o' the seekle;
His heart kep' goin' pittypat,
But hern went pity Zekle.

An' yet she gin her cheer a jerk
Ez though she wished him furder
An' on her apples kep' to work
Ez ef a wager spurred her.

"You want to see my Pa, I spose?"
"Wal, no; I come designin'—"
"To see my Ma? She's sprinklin' clo'es
Agin to-morrow's i'nin'."

He stood a spell on one foot fust
Then stood a spell on tother,
An' on which one he felt the wust
He couldn't ha' told ye, nuther.

Sez he, "I'd better call agin';"
Sez she, "Think likely, Mister;"
The last word pricked him like a pin,
An'—wal, he up and kist her.

When Ma bimeby upon 'em slips,
Huldy sot pale ez ashes,
All kind o' smily round the lips
An' teary round the lashes.

Her blood riz quick, though, like the tide
Down to the Bay o' Fundy,
An' all I know is they wuz cried
In meetin', come nex Sunday.

MAHMOOD THE IMAGE-BREAKER.

Old events have modern meanings; only that survives
Of past history which finds kindred in all hearts and
lives.

Mahmood once, the idol-breaker, spreader of the Faith,
Was at Sumnat tempted sorely, as the legend saith.

In the great pagoda's centre, monstrous and abhorred,
Granite on a throne of granite, sat the temple's lord.

Mahmood paused a moment, silenced by the silent face
That, with eyes of stone unwavering, awed the ancient place.

Then the Brahmins knelt before him, by his doubt made bold,
Pledging for their idol's ransom countless gems and gold.

Gold was yellow dirt to Mahmood, but of precious use,
Since from it the roots of power suck a potent juice.

"Were yon stone alone in question, this would please me well,"
Mahmood said; "but, with the block there, I my truth must sell.

"Wealth and rule slip down with Fortune, as her wheel turns round;
He who keeps his faith, he only cannot be discrowned.

"Little were a change of station, loss of life or crown,
But the wreck were past retrieving if the Man fell down."

So his iron mace he lifted, smote with might and main,
And the idol, on the pavement tumbling, burst in twain.

Luck obeys the downright striker; from the hollow core,
Fifty times the Brahmins' offer deluged all the floor.

Holmes.—Of the Brahmin caste of Boston, Dr. Oliver Wendell Holmes (1809-1894) is the most widely recognized representative. In fact, he invented the term to designate the most cultured descendants of the early colonial families. He was born at Cambridge, the son of Rev. Abiel Holmes, who wrote *Annals of America* (1805). While a student at Harvard, Oliver, then seventeen, wrote the spirited lyric, *Old Ironsides,* which prevented the famous ship Constitution from being broken up. He graduated in the celebrated class of 1829, chose medicine as his profession and went to Paris for study. On his return, after three years' stay, he recited *Poetry, a Metrical Essay,* and thereafter was in frequent request as poet for special occasions. His first volume of poems contained, besides serious pieces, others in a humorous vein, such as *The Last Leaf, My Aunt, The Treadmill Song,* which were quickly circulated in newspapers. Dr. Holmes was chosen professor of anatomy and physiology at Dartmouth College, and held this position ten years. Thereafter he devoted himself to practice in Boston, but he had also a country residence at Pittsfield. In 1847 he was made professor at Harvard College. Besides numerous medical essays, he published several volumes of poems, *Urania* (1846), *Astræa* (1850) and *Songs in Many Keys* (1861). These poems exhibited the felicities and polish of the eighteenth century.

Holmes' rank as a poet was already established when the starting of the *Atlantic Monthly,* in 1857, gave a new field for his talent and called forth unsuspected powers. Being specially engaged as a contributor, he invented a new method of addressing the public. He presented himself as *The Autocrat of the Breakfast Table.* Thus he was enabled to utter aphorisms or lengthy monologues on all sorts of subjects, with occasional variations due to slight interruptions by the other boarders or the landlady's family, all of whom are briefly but effectively described. It is a reversal of the *Spectator's* club, for there the eponymous figure was dumb, while here he monopolized the wise and witty discourse, and yet in such a pleasing way as to furnish sufficient variety. Interspersed were humorous poems, as *The Wonderful One-Hoss Shay,* and serious ones, as *The Chambered Nautilus.* As time passed the Autocrat withdrew, but his place was promptly supplied by the Professor, who discoursed perhaps more learnedly, yet quite delightfully. Later still the Poet made his appearance and kept up the charm. The element of love was not excluded, but helped to bring matters to an effective climax.

Having fully secured an attentive and interested audience, Dr. Holmes tried a new venture in the singular story *Elsie Venner* (1861), which introduced the consideration of heredity and prenatal influence. *The Guardian Angel* (1868) is a character study of a more wholesome kind. Various articles which had appeared in the magazine were gathered and labeled *Soundings from the Atlantic* (1864). On his seventieth birthday the publishers of the *Atlantic* gave a breakfast in his honor, at which he read *The Iron Gate,* written for the occasion. Brief biographies of his friends, Motley (1879) and Emerson (1884), shed light on himself as well as the subject. After some years, in which the genial doctor did less for his favorite *Atlantic,* he came back smiling and brisk as ever, and discoursed wittily as of old, but this time *Over the Teacups.* His last visit to Europe was pleasantly recorded in *Our Hundred Days in Europe* (1887).

Holmes throughout his career was an optimist. He hated but few things that were esteemed by other people, but among the few were Calvinism and homœopathy. Against these pet aversions he seldom lost an opportunity to have his fling. But in general he was tender as well as witty. He delighted to bring together things widely separated, so as to give a pleasing surprise. His mind was discoursive and independent; his opinions were so smartly stated that they seemed novel when in fact they were common. He had made such an impression as a comic writer by some early poems that he was tempted to keep up the reputation. But it is to his credit that even in the *Autocrat* he did not refuse such a noble poem as *The Chambered Nautilus.* This was favorite, but others may be placed beside it, as *The Voiceless* and *Sun and Shadow.*

OLD IRONSIDES.

Ay, tear her tattered ensign down!
  Long has it waved on high,
And many an eye has danced to see
  That banner in the sky;
Beneath it rung the battle shout,
  Aud burst the cannon's roar;
The meteor of the ocean air
  Shall sweep the clouds no more.

Her deck, once red with heroes' blood,
  Where knelt the vanquished foe,
When winds were hurrying o'er the flood,
  And waves were white below,
No more shall feel the victor's tread,
  Or know the conquered knee—
The harpies of the shore shall pluck
  The eagle of the sea.

O, better that her shattered hulk
  Should sink beneath the wave:
Her thunders shook the mighty deep,
  And there should be her grave;
Nail to the mast her holy flag,
  Set every threadbare sail,
And give her to the god of storms
  The lightning and the gale!

THE OLD MAN DREAMS.

O for one hour of youthful joy!
  Give back my twentieth spring!
I'd rather laugh a bright-haired boy
  Than reign a gray-beard king!

Off with the wrinkled spoils of age!
  Away with learning's crown!
Tear out life's wisdom-written page,
  And dash its trophies down!

One moment let my life-blood stream
  From boyhood's fount of flame!
Give me one giddy, reeling dream
  Of life all love and fame!

—My listening angel heard the prayer,
  And calmly smiling, said,
"If I but touch thy silvered hair,
  Thy hasty wish hath sped.

"But is there nothing in thy track
  To bid thee fondly stay,
While the swift seasons hurry back
  To find the wished-for day?"

—Ah, truest soul of womankind!
  Without thee, what were life?
One bliss I cannot leave behind:
  I'll take—my—precious—wife!

—The angel took a sapphire pen
  And wrote in rainbow dew,
"The man would be a boy again,
  And be a husband too!"

—"And is there nothing yet unsaid
  Before the change appears?
Remember, all their gifts have fled
  With those dissolving years!"

Why, yes; for memory would recall
  My fond paternal joys;
I could not bear to leave them all;
  I'll take—my—girl—and—boys!

The smiling angel dropped his pen—
  "Why this will never do;
The man would be a boy again,
  And be a father too!"

And so I laughed—my laughter woke
  The household with its noise—
And wrote my dream, when morning broke,
  To please the gray-haired boys.

Whittier.—The Quaker spirit is not favorable to the arts. The Friends are trained to repress strong feeling, to prevent its outbursts, to walk humbly with God. Meek Bernard Barton was their only poet in England; John Greenleaf Whittier (1808-1892) their only representative in America. He was born at Haverhill, Massachusetts, had scanty education and worked on a farm. Yet he showed talent for writing, and contributed to newspapers. His early poems, *Mogg Megone* (1836) and the *Burial of Pennacook,* are versifications of Indian stories. In his *Song of the Green Mountain Boys,* published anonymously, his poetic impulse carried him beyond the limits of his sect. At an early age he joined in the anti-slavery movement, and in its behalf he edited newspapers in Boston and Philadelphia. In the latter his printing office was burned by a mob in 1839. In 1840 he fixed his residence at Amesbury, Massachusetts. There his sister, and afterward his niece, abode with him. His health had always been delicate, yet he outlived these housekeepers, and for the last twenty years of his life he had to depend on those who were not of his kin.

Whittier steadily persevered in writing poems, and from time to time gathered them into volumes, as *Voices of Freedom* (1841), *The Panorama* (1856), *The Chapel of the Hermits* (1853), *Home Ballads* (1860). While steadfast in his adherence to Quaker practice, he was a fiery apostle of human brotherhood. His moral reprobation of slavery made him condone the war as the necessary means of its abolition. He was on the alert to discover in the incidents of the conflict suitable themes for his muse. To this vigilance was due his ballad of *Barbara Frietchie* (1862), which mingled devotion to the national flag with a kindly recognition of Stonewall Jackson. The incident, however, has been pronounced mythical. Whittier had become a regular contributor to the *Atlantic Monthly,* and after the war he published in it many New England ballads. His masterpiece, *Snowbound* (1865), is an artistic picture of the farmer's household closely imprisoned by the wintry storm. *The Tent on the Beach* (1867) is a poetic rendering of the gathering of literary friends, who tell characteristic tales.

Next to Longfellow, Whittier has been the most popular of American poets. His subjects have been taken chiefly from his own time and country, and have concerned the common experiences of mankind. His style is perfectly clear, his diction often homely. The faults of provincialism in rhyme or accent are easily overlooked when the mind is fixed on the thoughts presented. Whittier's poetry is sincere and habitual. He has described the scenery of New England and made it familiar in the popular mind. He has put in verse many touching stories drawn from old Quaker records, so as to make them universally known. Other stories teaching similar lessons were readily versified. He wrote no songs, as did Burns, but by expressing the genuine feelings of the mass of the people, strengthening their faith and removing doubts, he became their poet laureate.

SKIPPER IRESON'S RIDE.

Of all the rides since the birth of time,
Told in story or sung in rhyme—
On Apuleius's Golden Ass,
Or one-eyed Calendar's horse of brass,
Witch astride of a human back,
Islam's prophet on Al-Borák—
The strangest ride that ever was sped
Was Ireson's, out from Marblehead!
Old Floyd Ireson, for his hard heart,
Tarred and feathered and carried in a cart
By the women of Marblehead!

Body of turkey, head of owl,
Wings a-droop like a rained-on fowl,
Feathered and ruffled in every part,
Skipper Ireson stood in the cart.
Scores of women, old and young,
Strong of muscle and glib of tongue,
Pushed and pulled up the rocky lane,
Shouting and singing the shrill refrain:
"Here's Flud Oirson, fur his horrd horrt,
Torr'd an' futherr'd an' corr'd in a corrt
By the women o' Morble'ead!"

Wrinkled scolds with hands on hips,
Girls in bloom of cheek and lips,
Wild-eyed, free-limbed, such as chase
Bacchus round some antique vase,
Brief of skirt, with ankles bare,
Loose of kerchief and loose of hair,
With conch-shells blowing and fish-horns' twang,
Over and over the Mænads sang:
"Here's Flud Oirson, fur his horrd horrt,
Torr'd an' futherr'd an' corr'd in a corrt
By the women o' Morble'ead!"

Small pity for him!—He sailed away
From a leaking ship, in Chaleur Bay—
Sailed away from a sinking wreck,
With his own town's-people on her deck!
"Lay by! lay by!" they called to him.
Back he answered, "Sink or swim!
Brag of your catch of fish again!"
And off he sailed through the fog and rain!
Old Floyd Ireson, for his hard heart,
Tarred and feathered and carried in a cart
By the women of Marblehead!

Fathoms deep in dark Chaleur
That wreck shall lie forevermore.
Mother and sister, wife and maid,
Looked from the rocks of Marblehead
Over the moaning and rainy sea—
Looked for the coming that might not be!
What did the winds and the sea-birds say
Of the cruel captain who sailed away?—
Old Floyd Ireson, for his hard heart,
Tarred and feathered and carried in a cart
By the women of Marblehead!

Through the street, on either side,
Up flew windows, doors swung wide;
Sharp-tongued spinsters, old wives gray,
Treble lent the fish-horn's bray.
Sea-worn grandsires, cripple-bound,
Hulks of old sailors run aground,
Shook head, and fist, and hat, and cane,
And cracked with curses the hoarse refrain:
"Here's Flud Oirson, fur his horrd horrt,
Torr'd an' futherr'd an' corr'd in a corrt
By the women o' Morble'ead!"

Sweetly along the Salem road
Bloom of orchard and lilac showed.
Little the wicked skipper knew
Of the fields so green and the sky so blue.
Riding there in his sorry trim,
Like an Indian idol glum and grim,
Scarcely he seemed the sound to hear
Of voices shouting, far and near:
"Here's Flud Oirson, fur his horrd horrt,
Torr'd an' futherr'd an' corr'd in a corrt
By the women o' Morble'ead!"

"Hear me, neighbors!" at last he cried—
"What to me is this noisy ride?
What is the shame that clothes the skin
To the nameless horror that lives within?
Waking or sleeping, I see a wreck,
And hear a cry from a reeling deck!
Hate me and curse me—I only dread
The hand of God and the face of the dead!"
Said old Floyd Ireson, for his hard heart,
Tarred and feathered and carried in a cart
By the women of Marblehead!

Then the wife of the skipper lost at sea
Said, "God has touched him!—why should we?"
Said an old wife mourning her only son,
"Cut the rogue's tether and let him run!"
So with soft relentings and rude excuse,
Half scorn, half pity, they cut him loose,
And gave him a cloak to hide him in,
And left him alone with his shame and sin.
  Poor Floyd Ireson, for his hard heart,
  Tarred and feathered and carried in a cart
    By the women of Marblehead!

Hawthorne.—The greatest American romancer is Nathaniel Hawthorne (1804-1864). He was born at Salem, Massachusetts, and in that once flourishing, but then somewhat decayed, yet picturesque, seaport spent his childhood. After the death of his father, who had been a sea captain, his mother seldom left her room. At the age of twelve Nathaniel went to live on his grandfather's farm on Sebago Lake in Maine, on the border of the forest. He graduated at Bowdoin College in 1825, in the same class with Longfellow. Hawthorne then returned to Salem and shared the seclusion of his mother and sisters. He read much, and as he afterward said, "I passed the day in writing stories and the night in burning them." He left the house only in the evening for a solitary ramble. Whatever his natural disposition may have been, his early training would seem enough to shroud his spirit in gloom. One of his ancestors, Judge Hathorne (for so the name was originally spelled), had sentenced some of the Salem witches to death, and the imaginative descendant's mind dwelt on the fact with mingled horror and pity.

Hawthorne's first publication, *Fanshawe* (1825), issued anonymously, was a gloomy tale which received no attention from the public. Some of his short stories were sent to Samuel G. Goodrich, better known as "Peter Parley," the prolific author of instructive books for boys, and were published in *The Token,* one of the literary annuals then in vogue. Goodrich also obtained Hawthorne's assistance in some of his own enterprises. Slowly the beauty and weird power of his tales won recognition, yet in the preface of *Twice-Told Tales* (1837), Hawthorne spoke of himself as "the obscurest man of letters in America." Longfellow, in the *North American Review,* gave the book generous praise, which it fully deserved for its exquisite contents. Poe also declared that the author of these tales would put himself at the head of imaginative literature if he should discard allegory. But Hawthorne adhered to the manner he had learned from the German, Tieck. In writing for children, however, he used no allegory, came out of his wonted gloom and wore a cheerful air. The first example of this kind was *Grandfather's Chair* (1841), in which the chief features of New England history are displayed in a series connected with a chair brought over by an original settler.

Hawthorne could not live on the meagre support drawn from his stories. The historian Bancroft, therefore, when collector of customs at Boston, appointed him a weigher and gauger. But a political change in the administration threw him out two years later. In 1842 he married Miss Sophia Peabody, and they went to live at Concord in the historic gambrel-roofed house which later gave name to his *Mosses from an Old Manse* (1846), a collection of stories, chiefly allegorical. Still struggling and unsettled, he was induced to join the Brook Farm community. This curious social experiment proved little to his liking. His own account is, "I went to live in Arcadia, and found myself up to my chin in a barnyard." Yet, from his observation there, his genius later evolved *The Blithedale Romance* (1852). The most striking figure, Zenobia, was drawn from the gifted Margaret Fuller, though the circumstances of her story are greatly altered.

Political fortune came again to his aid, and he was made surveyor in the custom house at his native Salem. In the preface to *The Scarlet Letter* (1850) he has related this new experience with surprising freedom. The scene of the main story was laid among the early settlers. Hester Prynne was condemned to wear on her breast the scarlet A in token of her crime. Her husband, old Roger Chillingworth, has followed from afar, and keeps close watch on her movements. The minister, Arthur Dimmesdale, is allowed, indeed required, to speak to the sinner, that she may be brought to repentance. But what is the horror of the beholders when, after his public rebuke of the guilty one, he himself takes his place beside her on the scaffold of shame. And yet there is mitigation in the agony of the final punishment, when the beautiful Pearl, the offspring of sin, innocently stands with them. The deep probing of the human heart and the clear exposure of elemental passions make this a masterpiece of psychology, and the greatest book written by an American. But the story in its externals is not to be taken as a faithful picture of Puritan life. It is a romance, an exaggeration of its possibilities. The very title of the book is a figment of the author's fancy.

Hawthorne next went to live at Lenox, in western Massachusetts, then little frequented. Here he wrote *The House of Seven Gables* (1852), a story of more repressed intensity, with more humor and sunshine, yet showing the same power as *The Scarlet Letter*. Hepzibah, a sad relic of New England aristocracy, is reduced to keep a penny store, and stern old Judge Pyncheon moves in solitary grandeur. Hawthorne returned to Concord and bought the house called the Wayside. But when his college-mate, Franklin Pierce, was nominated for the Presidency, Hawthorne, always his friend, being requested, wrote a campaign biography. In due time the writer was appointed consul at Liverpool, and went abroad for seven years. An interesting record of his sojourn in England and later travels in France and Italy is preserved in the series of *Notebooks*, which have all been published. But the most valuable result is *The Marble Faun* (1860), his longest romance. A strange mystery pervades the story, and the impression is produced that Donatello is a survival of preternatural beings hardly yet human. In this half-developed, innocent creature the experience of sin awakens a slumbering soul. The book is largely occupied with artists' life in Rome, and has become a favorite with tourists. *Our Old Home* (1863) is composed of charming descriptive papers on England. Hawthorne died suddenly at the White Mountains, where he had gone with his friend, Pierce. He was but sixty years of age.

Hawthorne's wide experiences in the later part of his life gave greater range and fullness to his sketches. His style also steadily improved until it attained exquisite perfection. His *American Note Books* contain not only the first suggestions of some of his finished stories but abundance of hints for plots and descriptions which were never written out. To the children's books already mentioned should be added the *Wonder Book* and *Tanglewood Tales*, remarkable "Gothicizing" of the best stories of Greek mythology.

Hawthorne, while ever on friendly terms with Emerson and the coterie of the *Atlantic Monthly*, cared little for Transcendentalism, abolitionism or political reforms. He was a silent observer, and used his insight into the heart only for artistic literary purposes. But his short stories are exquisite gems, and his romances, slowly wrought from homely, unpromising material, have become the most precious treasures of American literature.

Bancroft.—When fifty years had proved the solid and lasting value of the Constitutional government established in the United States, it was time for the historian to state and prove how this new nation had been formed and reared. For this momentous task George Bancroft (1800-1891) came forward, and after fifty years of labor accomplished his purpose in a monumental work. He was born at Worcester, Massachusetts, the son of a minister who, in youth, had fought at Bunker Hill. After graduating at Harvard he studied in German universities under the best teachers of history. On his return, wishing to introduce the Prussian educational methods, he opened the famous Round Hill School at Northampton. After translating his preceptor Heeren's *Politics of Ancient Greece*, he began his studies for his stupendous work. He was filled with enthusiasm for the grandeur of his theme, and he had been trained with conscientious regard for the truth of facts. The first volume appeared in 1834, and was hailed with delight by the American people. The author's enthusiasm was manifested in rather exuberant rhetoric, but the feeling was contagious. But foreign critics objected to his extravagant laudations of democracy as the perfect government.

In the meantime Bancroft was active in politics, advocating manhood suffrage. In 1838 he was made collector of the port of Boston, and in 1845 Secretary of the Navy in President Polk's cabinet. He established the Naval Academy at Annapolis. By his orders California was seized at the opening of the Mexican War. In 1847 Bancroft was sent as Minister to Great Britain. There he had unusual facility of access to archives, and procured new and valuable material. Two volumes of his history were written in London. After his return, in 1849, he fixed his residence in New York city, and devoted his time to the history. Particular statements in some of the later volumes were questioned, especially by descendants of persons mentioned somewhat unfavorably. Various pamphlets were published in what was humorously called "The war of the grandfathers." Bancroft's devotion to historical truth was fully proved, even though in some cases he had to modify his first assertions.

In 1866, at the request of Congress, Bancroft delivered the memorial address on President Lincoln. In 1867 he was sent as Minister to Russia, and in the next year was transferred to Germany, where he remained till 1874. His diplomacy was successful in establishing the American doctrine of expatriation. His later years were spent in Washington, varied with summer residence in Newport. In this period his account of the formation of the Federal Constitution was completed, thus extending his work to twelve volumes.

During his career Bancroft had delivered many addresses and published many essays, but his fame rests entirely and securely on his great history. In it are set forth, with abundant detail, the wonderful contribution which America has made to the theory and practice of government. At the same time its development is closely connected with the progress of events in the Old World.

Prescott.—The most brilliant and famous of American historians is William Hickling Prescott (1796-1859), whose work was performed under difficulties sufficient to appal the most determined investigator. He was born at Salem of wealthy parents, and was the grandson of Captain Prescott, who commanded the American forces at Bunker Hill. He graduated from Harvard in 1814, but had already met the misfortune which threatened his usefulness. While a junior he was struck in the left eye with a piece of bread, thrown by a fellow-student. The sight of that eye was destroyed, and the right eye was also seriously affected. But Prescott set himself resolutely to accomplish a grand historical task. He selected the Spanish conquest of America as a theme worthy of full examination and report. With the aid of secretaries he pursued his labors for more than ten years before he was able to send forth at his own expense the *History of Ferdinand and Isabella* (1838). Its merit was at once acknowledged throughout the world. It was translated into Spanish, Italian and German. Then followed *The Conquest of Mexico* (1843), *The Conquest of Peru* (1847) and *Philip the Second* (1855), which he did not complete. During the progress of these main works Prescott had written also critical and miscellaneous articles for the *North American Review,* which were afterward collected in a volume. In order to accomplish this vast amount his time was exactly arranged. Besides employing amanuenses he used a noctograph. The authorities for research were collected at large expense. After they were read to him and thoughtfully considered, he made a mental outline and even elaborated the style before final dictation. Though he traveled in Europe he never visited the scenes of his histories.

Prescott's works are distinguished by picturesque narration in a dignified style. He endeavored to arouse interest in his narrative, and his continued popularity attests his success. While he carefully weighed the authorities on which he depended, more recent investigators have proved that the original Spanish writers misinterpreted and misrepresented many facts and customs which they observed.

Motley.—Love of liberty was the inspiring motive of the historical labors of John Lothrop Motley (1814-1877). He was born at Dorchester, Massachusetts, and educated at Bancroft's Round Hill School and Harvard. After graduating at the latter he went to Göttingen and Berlin for further study. There he formed a warm friendship with Bismarck. After his return he wrote *Morton's Hope* (1839), a story of the Revolution, and *Merry Mount* (1849), a new relation of the early days of Massachusetts. But more valuable were his historical articles in the *North American Review.* From these he proceeded to his *Rise of the Dutch Republic* (1856). In prosecution of his labors on it he had spent five years in examining the European archives. The hero of his work is William the Silent, the statesman who overthrew the tyrannical power of Philip II and his viceroy, the Duke of Alva. The author's impetuous graphic style was well suited to his dramatic narrative of the triumph of liberty. In the *History of the United Netherlands* (1860) the author related how the little nation William had founded went on to win a place among the great powers of Europe.

Motley was an ardent upholder of the Union cause in the American Civil War. As minister to Austria he maintained the national dignity. He resigned in 1867, but two years later was sent as minister to Great Britain. But he became involved in the quarrel between President Grant and Senator Sumner and was recalled in 1870. Motley, at intervals during his diplomatic work, had prosecuted historical research. By *The Life and Death of John of Barneveld* (1874) the narrative was continued to 1620. Motley had hoped to bring it down to the Peace of Westphalia in 1648, but his health failed. He died at Dorchester, in England.

Motley rejected the measured, dignified style of Prescott and used vehement, thrilling declamation in telling the uprising of the brave and earnest people of Holland against the bloody despotism of Spain. The siege of Antwerp and the sack of the cathedral, and the defeat and dispersion of the Spanish Armada, are described with marvelous force. Among the great historical personages depicted, besides William the Silent, are Philip II, Henry of Navarre, the bloodthirsty Duke of Alva, and Queen Elizabeth.

Mrs. Stowe.—The most widely circulated American novel is *Uncle Tom's Cabin,* which has not only been published in many editions in America and England, but has been translated into all the prominent languages of Europe and some of the Asiatic tongues. The author, Mrs. Harriet Beecher Stowe (1812-1886), was the daughter of Rev. Lyman Beecher, a prominent Presbyterian minister, and sister of the more famous Rev. Henry Ward Beecher. She was born at Litchfield, Connecticut, and early displayed great talent. When she was but fourteen she taught in her sister's school. Her father removed to Cincinnati in 1832, and there she met Rev. Calvin E. Stowe, to whom she was married in 1836. During her eighteen years' residence in Cincinnati she learned much about slavery as practised in Kentucky. In 1850 Prof. Stowe was called to a professorship at Bowdoin College. There his wife wrote *Uncle Tom's Cabin,* which first appeared serially in *The National Era,* an anti-slavery paper published in Washington. But it attracted little attention until issued in book form at Boston in the next year. Then the demand for it steadily grew. The story was dramatized and put on the stage, and the book sold all the faster. It fanned the flames of political discussion. It was bitterly denounced in the Southern States, and several replies to it were made, some in the form of novels.

The main story may be briefly outlined. Uncle Tom, a pious negro, is sold by his master, a Kentucky farmer, taken down the Mississippi by a slave dealer, and sold at New Orleans to St. Clair, a careless gentleman, whose child, Eva, became warmly attached to old Tom. But when St. Clair is suddenly killed, the old negro is sold to the brutal Legree, by whom he is finally flogged to death. Other characters of various kinds are introduced, and the story of George and Eliza Harris is interwoven. In spite of the denials of many Southern people, the picture of slavery in its various phases was accepted as correct. Mrs. Stowe afterward issued a *Key to Uncle Tom's Cabin,* giving statements from newspapers and other sources to substantiate its general accuracy.

In 1857 she published *Dred,* a story of a slave insurrection in Virginia. Before these novels she had written slight sketches of New England life in *The Mayflower.* With more experience she wrote *The Minister's Wooing,* drawn from the life of the theologian, Samuel Hopkins, and exhibiting New England life in the middle of the eighteenth century. In 1860 Mrs. Stowe visited Europe, where she was received with great honor. The knowledge of Italy thus obtained was utilized in *Agnes of Sorrento* (1862), which treated of the times of Savonarola. *The Pearl of Orr's Island* is an idyll of the New England coast. Later, she moralized on phases of domestic life in *My Wife and I* and *Pink and White Tyranny.* But more enjoyment was found in her sketches of quaint Yankee characters in *Old Town Folks, Poganuc People* and *Sam Lawson's Fireside Stories.* Sam is a veritable Yankee, readily identified.

Bayard Taylor.—One of the writers who was closely connected with New York publications was of Pennsylvania Quaker birth. This was Bayard Taylor (1825-1878), who was best known as a writer of travels, but aimed to be a poet. Born at Kennett Square, he learned the printer's trade, and at the age of twenty went to Europe. His support was derived from American newspapers, to which he wrote letters. When collected, they were called *Views Afoot, or Europe Seen With Knapsack and Staff* (1846). New travels followed. He went to California, Russia, Syria, Central Africa, Northern Europe, India, China and Japan. Ten volumes were occupied with prose descriptions, and there were also *Rhymes of Travel, California Ballads* and *Poems of the Orient.* Still his heart cherished his native place, and it was the scene of his novels, *Hannah Thurston* and *A Story of Kennett.* In *John Godfrey's Fortune* his own career as printer and newspaper editor was partly sketched. After building a country home at Kennett Square, he found that the neighborhood was no longer congenial to his cosmopolitan habits. His second wife was the daughter of a German astronomer. Taylor wished to realize in himself the noble intellectual life of Goethe. His aspiration seemed to be in process of fulfillment when he was appointed Minister to Germany in 1878, but he died before the close of the year. He had made a masterly translation of Goethe's *Faust* in the metres of the original. His long poems are *Prince Deukalion,* a dramatical outline of the progress of civilization, and *The Masque of the Gods,* which describes vast movements in human affairs. *Lars* is a Norwegian pastoral. But his short lyrical pieces, relating to the Orient or to his Pennsylvania home, are more regarded.

Read.—The artist-poet, Thomas Buchanan Read (1822-1872) is perhaps best known by his spirited ballad *Sheridan's Ride.* His early poems were praised by Longfellow and later ones obtained favor from British critics. Yet he has had less popularity than he deserves. He was born in Chester county, Pennsylvania, but when fourteen years old was taken to Cincinnati, where he entered the studio of the sculptor, S. V. Clevenger. Read, wishing to become a painter, went to Boston in 1840. While winning recognition in his art, he contributed poems to periodicals. In 1846 he removed to Philadelphia, and there edited *The Female Poets of America* (1848). He went to Florence, Italy, in 1850, and thenceforth resided chiefly in Europe, but made several visits to Philadelphia and Cincinnati.

After he had issued four volumes of poems, he published *The New Pastoral* (1855), an American idyl of peace. Early in the Civil War, his patriotism stirred him to produce *The Wagoner of the*

Alleghanies (1862), a narrative poem of the Revolution, recalling for a new generation the spirit of '76. One of its lyrics, *The Brave at Home,* is notable for beauty and simplicity. Two years later Sheridan's ride from Winchester to the battle stirred the hearts of Northern people. Read, then in Cincinnati, hastily wrote his ballad for recitation by his friend, the actor, James E. Murdock, who had devoted his elocutionary talent to the service of the Sanitary Commission. It was soon declaimed throughout the North. After the war Read continued to combine painting and sculpture with poetry and had an international reputation. But his Bohemian manner of life created some prejudice against him. His poems are thoroughly American, showing genuine love of nature and chivalric respect for womanhood.

Mitchell.—Under the pen name of Ik Marvel, Donald Grant Mitchell wrote several books which have had wide popularity. He was born at Norwich, Connecticut, in 1822, was educated at Yale College and became a lawyer and journalist. His first publications were the fruits of travel and observation in Europe, *Fresh Gleanings* (1847), and *The Battle Summer* (1848), the year of several revolutions. But his best-known books are *Reveries of a Bachelor* (1850) and *Dream Life* (1851). The former professed to record whimsies and reflections which brother bachelors were "too cautious to lay before the world." The latter consists of a man's day-dreams from boyhood to old age, showing early aspirations shading off into vague reminiscences. After holding a consulship at Venice for a term, Mitchell settled near New Haven in 1858, and from it wrote many delightful essays on rural life. They are gathered in *My Farm at Edgewood, Wet Days at Edgewood* and *Rural Studies.* He also lectured in various places on *English Lands, Letters and Kings* and *American Lands and Letters.* These books are pleasant, chatty reviews of the literature of the great English-speaking nations.

Simms.—Not less than seventy volumes was the literary output of William Gilmore Simms (1806-1870), who is chiefly known as a Southern novelist. Born at Charleston, South Carolina, he became a lawyer. From childhood he was fond of writing, and before reaching manhood had published some volumes of poetry. He was editor and part proprietor of a newspaper which failed on account of his advocacy of the Union during the Nullification troubles. He then devoted himself to literature, and for a time resided in Massachusetts. In 1835 he published his best story, *The Yemassee,* exhibiting Indian life in the Southern States. For twenty-five years he poured forth a stream of romances in the style of Scott and Cooper. Among those founded on Revolutionary events are *The Partisan, Mellichampe,* and *The Scout.* There were also romances of the backwoods, as *Guy Rivers* and *Beauchampe.* All are full of action and intrigue, but were written too hastily to be of lasting value. Simms wrote also *South Carolina in the Revolution* and other historical and biographical works, and contributed to magazines and reviews. The collected edition of his writings was reduced to nineteen volumes. He was a typical Southern gentleman, living in fine style on a plantation and dispensing liberal hospitality. His numerous poems are forgotten and few of his romances are now read.

CHAPTER IV.

From the Civil War to the Present Time.

The New Era in Literature.—The twenty years before the Civil War had been the most fruitful period of American literature. In it flourished Longfellow, Lowell, Holmes, Whittier, Hawthorne, Mrs. Stowe and others. These writers, who have been treated in the previous chapter, did important work also in the present period, but these later publications show new influences.

The tremendous upheaval of the war did not destroy literary activity. Rather it deeply stirred the emotions of the people and aroused more strenuous intellectual effort. The habit of reading was more widely spread, and writers found it more easy to reach an audience. Magazines flourished in an unwonted degree and drew forth the talent of poets and prose writers. The contest with slavery had roused the moral feelings, and when that national evil was abolished, those who had been active in opposition found other social problems to discuss and new reforms to agitate.

To the strife of civil war succeeded a happy period of centennial celebrations of events connected with the foundation of the nation. The historic imagination was thus stimulated, and both North and South united in chanting the praises of the founders. New studies were made of the principles of government and of the development of the American people. A new school of historians gave greater prominence to the general condition of the people as the vital element in national welfare.

In this period the manifold contrasts of life in the Mississippi Valley and on the Pacific slope entered into literature. California, which had lain remote from the rest of the Union, was firmly bound by iron bands, and offered virgin themes to poet and romancer. From it came new types of character and a fresh development of the short story. Southern writers also contributed to Northern magazines poems and stories of the Civil War, and found sympathetic readers.

The Darwinian theory and the philosophy of Herbert Spencer found wide acceptance in the United States. Additions were made to them by John Fiske and other writers. The questions involved were discussed in many essays. Pessimism has obtained little support in America. The general attitude of writers is a cheerful optimism. They are satisfied with the world's progress and hopeful of the future.

Lanier.—For the opening of the Centennial Exhibition at Philadelphia Sidney Lanier (1842-1881) was chosen as the poet, though he was then unknown to the general public. He was born at Macon, Georgia, and was descended from a line of musicians, one of whom was in the court of Charles I. Lanier was a student at Oglethorpe College until he entered the Confederate service. Hardships of the war developed consumption, with which he struggled until the end, before he was forty. In the novel, *Tiger Lilies* (1867), he drew upon his war experiences. In 1873 he went to Baltimore as a musician, and in 1879 he was appointed lecturer on English literature in Johns Hopkins University. He had already edited for boys Froissart's *Chronicles*, Malory's *King Arthur*, Percy's *Reliques*, and the *Mabinogion*. His *Science of English Verse* (1880) was a technical study of the metrical structure of English poetry. *The English Novel* (1883) treated the subject according to the principles of evolution. Lanier's *Poems* (1884) were collected after his death. They are all musical, many of them really songs. His *Psalm of the West* is thoroughly American. *Corn*, *Clover*, *Tampa Robins*, *The Dove*, all attest his love of nature, which gives personality to all its products. In the same mystical way *A Ballad of Trees and the Master* represents the trees as sympathizing with Christ in his sufferings. *The Stirrup Cup* is a friendly challenge to Death. The mystical nature of his poems confines their appreciation to a select few.

Whitman.—The most debatable contribution to American literature was made by Walt Whitman (1819-1892). He was born on Long Island, his father being English and his mother Dutch. In boyhood he attended school in Brooklyn, and then became a printer. He wrote for newspapers and for a while published one. His delight was to mingle freely with workingmen. He edited the Brooklyn *Eagle* for a year, then journeyed through the South and West to New Orleans, getting employment in printing offices as he moved along. His return was made in the same way. In 1855 he published his *Leaves of Grass*, having set most of the type himself. It has no rhymes nor any regular forms of verse. Stanzas and lines were of various lengths. Slang and uncouth phrases were employed. There was a declaration of democratic sympathy with all classes of men, yet throughout it there was a superb egotism. The book was rereceived with general ridicule. But Emerson, ever generous and ready to help, wrote to the brother-author a letter of praise. The letter was published in the second edition of the *Leaves*, which contained matter much more objectionable than the first. Emerson took no further notice of the whimsical, unconventional genius. In New York City Whitman became a hero among young Bohemians. During the Civil War Whitman went to Washington and was a government clerk. Then he spent his time in visiting the wounded soldiers in the hospitals. After the war he was again a government clerk until 1873, when, after a stroke of paralysis, he removed to Camden, New Jersey. Here, in a small cottage, he was supported by the generosity of a few friends. During the war he had written *Drum Taps* (1866), and, some years later, *November Boughs*, *Specimen Days and Collect*, and *Good Bye, My Fancy*. But all these little groups were included in later editions of *Leaves of Grass*.

Whitman sought to represent American democracy, sometimes in the self-reliant, irreverent individual, sometimes in the swarming, restless multitude. At times he was bold to say things which decency forbids, at other times he seemed to express aspiration toward a pure humanity. A few scholars in America and in Europe approved his attempt, but he was nowhere accepted by the people. A few still find something admirable in his spirit or utterances. But the majority adjudge him as a harmless crank.

THE MIRACLES OF NATURE

(From *Leaves of Grass.*)

To me every hour of the light and dark is a miracle,
Every inch of space is a miracle,
Every square yard of the surface of the earth is spread with the same.
Every cubic foot of the interior swarms with the same.

. . . .

To me the sea is a continual miracle,
The fishes that swim—the rocks—the motion of the waves—the ships with men in them,
What stranger miracles are there?

. . . .

I was thinking the day most splendid, till I saw what the not-day exhibited;
I was thinking this globe enough, till there tumbled upon me myriads of other globes:
O, how plainly I see now that this life cannot exhibit all to me—as the day cannot;
O, I see that I am to wait for what will be exhibited by death.

. . . .

O Death!
O, the beautiful touch of Death, soothing and benumbing a few moments, for reasons.

. . . .

The earth never tires,
The earth is rude, silent, incomprehensible at first—
Nature is rude and incomprehensible at first;
Be not discouraged—keep on—there are divine things, well enveloped;
I swear to you there are divine things more beautiful than words can tell.

Holland.—A thorough New Englander, retaining much of the Puritan spirit, was Dr. Josiah Gilbert Holland (1819-1881). In spite of poverty he obtained an education and studied medicine. But his success was won as an editor. In 1849 he took charge of the *Springfield Republican,* and by well-directed energy gave it not merely local success but national reputation. In its columns he first published a *History of Western Massachusetts* and then an historical novel, *The Bay Path.* He inculcated moral and social duties in letters to various classes. As Timothy Titcomb he published *Letters to Young People, Married and Single,* teaching purity and true religion. His poetry was as pure and attractive as his prose. *Katrina* (1867) is an idyll of domestic happiness. In 1870 he went to New York to edit *Scribner's Magazine,* and by judicious management achieved the same success in a wider sphere. For it he wrote the novels, *Arthur Bonnicastle* and *Nicholas Minturn,* still retaining the didactic character of his earlier work.

H. H. Jackson.—Among the women writers of special ability is Helen Hunt Jackson (1831-1885). Writing under the initials "H. H.," she won high regard as a poet, then became better known as a descriptive writer by her *Bits of Travel,* and published some novels under the pen-name, Saxe Holm. Toward the close of her life she took up the cause of the Indians, showing the gross wrongs which had been done them by traders and officials. These were summed up in *A Century of Dishonor.* The powerful story, *Ramona,* was her final effort in their behalf.

Joaquin Miller.—Born in Indiana in 1841, Cincinnatus Hiner Miller was taken to Oregon in boyhood and afterward became a miner in California, but with poor success. He joined Walker's filibustering expedition to Nicaragua and then returned to Oregon to study law. He even became a county judge. He went to England in 1870, and there his *Songs of the Sierras* aroused high expectations. On his return to the United States he became a journalist, and added to his poems, *Songs of the Sunland, Songs of the Mexican Seas* and other pieces, besides a play on the Mormons, *The Danites.* He has also written prose sketches and fiction of California life.

Stoddard.—Though born at Hingham, Massachusetts, of a seafaring race, Richard Henry Stoddard (1825-1903) spent most of his life in New York City. He worked in an iron foundry, yet was able to write poetry of such beauty and power as to win for him a place close to Longfellow. He was thoroughly independent and would not cringe to win favor. He was employed in the Custom House from 1853 to 1870, and afterward in a city office. Eventually he became literary editor for the New York *Mail and Express.* Even when, in old age, blindness afflicted him he continued his editorial work. In 1880 his poems were collected in a large volume. They are characterized by lofty imagination, pure taste and tender feeling, kept free from mere sentiment. They have a wide range from pictures of nature to ballads of romance.

Harte.—The new aspects of life produced by the sudden influx of immigrants in the California mining region has been presented by several writers. Among these Francis Bret Harte (1839-1902) obtained distinction by his dramatic short stories. Born in Albany, New York, he went to California in 1854. He worked in the mines and wrote for newspapers, and was secretary of the mint at San Francisco. His *Condensed Novels* (1867) were smart parodies of the leading American and English novelists. He wrote also in verse, sometimes seriously, as in *John Burns at Gettysburg,* but usually in humorous guise, as in *The Pliocene Skull* and *The Society Upon the Stanislaus,* in which scientific speculation was brought into strange commingling with rude mining life. His most widely circulated poem was *Plain Language from Truthful James,* but commonly called *The Heathen Chinee,* from its exhibition of the unscrupulous trickery of the apparently guileless Chinese. In 1868 the *Overland Monthly* was started with Harte as editor. For its second number he wrote *The Luck of Roaring Camp.* The publisher feared the story would kill the venture, but it was received with loud acclaim as a true picture of mining life. Harte reeled off a string of such stories, sometimes with tragical endings. Among them were *Miggles, Tennessee's Partner, The Outcasts of Poker Flat.* In 1871 Harte removed to New York, where he continued writing in the same vein. In 1878 he was sent as American consul to Germany, and afterwards to Glasgow, but his time was chiefly spent in London with literary companions. His long novel, *Gabriel Conroy,* was not as successful as the short stories of the varied phases of California life.

Howells. — The most pleasingly realistic of American novelists is William Dean Howells. He was born at Martinsville, Ohio, in 1837, and was trained in his father's printing and newspaper office. At nineteen he went to the State capital to report the procedings of the Legislature. But he had higher aspirations, and in 1859, with his friend, John James Piatt, published a volume of poems. For the Presidential campaign of 1860 he wrote a biography of Abraham Lincoln. Being sent as consul to Venice, he made special study of Italian life and literature. His *Venetian Life* (1865) remains an admirable portraiture of the fascinating island city. On returning to America he settled in New York until made assistant editor of the *Atlantic Monthly* in 1871. Here were published his admirable portrayals of ordinary American life, commencing with *Their Wedding Journey,* and continued in *A Chance Acquaintance, A Foregone Conclusion, The Lady of the Aroostook, Dr. Breen's Practice.* The most forcible of these studies of American life is *The Rise of Silas Lapham,* a picture of the rise and fall of the fortunes of a Vermont countryman whose suddenly acquired wealth brings his family into cultivated Boston society. In 1886 Howells took charge of the *Editor's Study* in *Harper's Magazine,* and here set forth his ideas of the proper methods of writing novels. Romanticism and sensationalism are absolutely rejected. Character is revealed in ordinary incidents and conversation. His own work is the best illustration of his theory. *April Hopes* and *The World of Chance* are sketches of actual American life, with its variations and unexpected turns. In *A Hazard of New Fortunes* the same characters appear as in *Their Wedding Journey. The Undiscovered Country* is a story of modern spiritualism. *A Traveler from Altruria* shows the contrast between the real and the ideal. Some of his stories have been dramatized, though they are not usually adapted for the stage. In *Their Silver Wedding Journey* the characters of his early story again appear with such changes as time has necessarily produced upon them. All the pictures of this group are true to life. But Howells' work does not consist merely of snapshots. All his stories are artistically planned and carefully wrought. The moral is never obtruded nor thrust in at the end; it is interwoven in the development of the plot. Howells has pronounced Tolstoi the greatest novelist of this century, and has industriously explained his methods. In *Modern Italian Poets* he exhibited the productions of the nineteenth century. Howells has not entirely forsaken the Muse to whom he dedicated his first efforts in literature. In *Stops of Various Quills* (1895) he shows his interest in human progress.

Burroughs.—The best-known nature essayist is John Burroughs, who was born at Roxbury, New York, in 1837. His boyhood was spent on a farm, and after receiving education at an academy he taught school. He wrote for newspapers and became a clerk in the Treasury at Washington. Afterward he was made bank inspector. But his leisure was spent on a farm and in friendly study of nature. The titles of his books are often strongly suggestive of country sights, *Wake Robin, Birds and Poets, Locusts and Wild Honey, Fresh Fields, Signs and Seasons.* The essays reproduce the charm of outdoor life.

Cable.—Though born in New Orleans in 1844 and serving in the Confederate army, George Washington Cable eventually settled in Massachusetts. After the war he was a clerk and reporter for New Orleans newspapers. But in 1877 he begun to publish in *Scribner's Magazine* stories of the aristocratic creoles of New Orleans. When gathered in the volume *Old Creole Days* (1878) they proved still more popular. *The Grandissimes* (1880) was a novel of the same class, showing the strange mixture of whites and blacks, as well as of French and Americans in that city. *Madame Delphine* and *Dr. Sevier* continued the revelation of this community, previously unknown to literature. The scenes were generally laid in the time of the transition from French and Spanish rule to American, thus giving better scope for the author's fancy. The sensitive creoles resented the author's intrusion into their privacy, and were more seriously offended by the introduction of the quadroons as an essential element of society. Cable went on to sketch other strange features of Louisiana, particularly the Acadians who had been forced into exile from Nova Scotia. *Bonaventure* includes three of these stories. Cable wrote also a *History of New Orleans* (1883). After his removal to Massachusetts he engaged chiefly in religious work.

Henry James was born in New York City in

1843, the son of a scholarly Swedenborgian minister. He has spent most of his time in Europe, but is none the less distinctly American in spirit. Much of his work is devoted to showing the contrasts between Americans and Europeans, and also the contrast between the artistic and the ordinary person. The former was seen in *The American* (1877) and still more emphatically and pathetically in *Daisy Miller* (1878). His subjects belong to polite society, and his object is to delineate character by dialogue. He is a master of refined realism. Among his short stories are *The Madonna of the Future, The Lesson of the Master, What Maisie Knew*. One of his most popular long stories is *The Portrait of a Lady*. His early story, *Roderick Hudson,* has a tragic sequel in *The Princess Casamissima*. *The Tragic Muse* deals with English life. James has written also descriptive sketches of men and places, and discussed social topics in a well-bred manner.

Parkman.—In some respects akin to the career of Prescott is that of his noble successor, Francis Parkman (1823-1893). Descended from the first settlers of Massachusetts and born in Boston, he was educated at Harvard and studied law. He early chose as a suitable theme for historical research and presentation the great conflict between France and England for the possession of North America. To understand fully the nature of this struggle he determined to study the manners of Indians as remote as possible from European civilization. Therefore, in 1846, he set out for the Rocky Mountains and sojourned among the Dakotas. In spite of his strong constitution, the privations of this residence among savages rendered him an invalid for the rest of his life. His first book, the *Oregon Trail* (1849), related his experience. The next was *The Conspiracy of Pontiac* (1851), relating the most remarkable effort of the Indians to check and overthrow the onward progress of the English in subduing the continent. Parkman's works, while all forming a grand series, were issued separately and not in the chronological order of the events which they describe. They comprise *The Pioneers of France in the New World* (1865), *La Salle and the Discovery of the Great West* (1869), *The Jesuits in North America* (1867), *The Old Regime in Canada* (1874), *Count Frontenac and New France Under Louis XIV* (1877), *A Half Century of Conflict* (1892), *Montcalm and Wolfe* (1884). In prosecution of his researches Parkman went several times to France to examine the national archives. Yet, throughout his labors, he was a victim of distressing sickness, so that often he could work but a few minutes at a time. As an alleviation of physical pain he gave attention to horticulture, and even taught that subject in the Harvard Agricultural School. He published *The Book of Roses,* as well as a novel. The wonder of his afflicted life is that he accomplished so thoroughly the grand design which he had purposed.

The interest of his subject reaches even beyond the American continent. It extended to the whole world, for the question to be decided was whether France or England was to take the lead in subduing the uncivilized parts of the earth. The struggle for Canada gave to England the prerogative for this mission. Throughout his work Parkman rendered exact justice to all the actors in the great drama which he reviewed. Not by a single performance did he leap into fame. Only when his vast work was practically completed was its importance and magnificence fully appreciated.

Fiske.—In the early part of his public career John Fiske (1842-1901) was mostly occupied in discussions as the advocate of evolution and the synthetic philosophy of Herbert Spencer, but in the latter part he gave attention chiefly to American history. He was born at Hartford, Connecticut, the son of Edmund B. Green, but at the age of thirteen took the name John Fiske from one of his ancestors. He was always a hard student. At an early age he became versed in many languages, ancient and modern. He graduated at Harvard in 1863 and at its Law School in 1865, but never practised law. He was already busy as a writer, and for two years he lectured on philosophy in Harvard and afterward was assistant librarian there. On giving up this position he devoted himself entirely to lecturing and authorship, making each assist the other.

Fiske's first important writing was *Outlines of Cosmic Philosophy* (1871), which Darwin praised as the most lucid exposition he had ever read. Fiske claimed to have made an important contribution to the theory of evolution by showing the importance of infancy in the development of the higher complex animals. The prolongation of infancy is necessary for the young child and has important reflex action on the parents, giving rise to altruism and gentler feelings. While preparing to write a work on the early Aryans, Fiske published *Myths and Myth Makers* (1874). Other philosophical writings are *Excursions of an Evolutionist, The Destiny of Man, The Idea of God as Affected by Modern Knowledge* (1884).

When the Old South Meeting House in Boston was threatened with destruction in 1879 Fiske was invited to deliver a course of lectures on *Ameri-*

can Political Ideas for the benefit of the fund for its preservation. This course was popular and was repeated elsewhere. Thereby his attention was directed to the subject of American history as requiring elucidation. The result is seen in his series of works, *The Discovery of America, The Beginnings of New England, Virginia and Maryland, The Middle Colonies, The American Revolution* and *The Critical Period in American History.* Gradually the series was taking its final shape, when the author died suddenly.

Eggleston.—Before becoming an historian, Edward Eggleston (1837-1903) had been a Methodist preacher and a popular novelist. Born at Vevay, Indiana, of a father who had come from Virginia, he went to Minnesota in youth for the sake of his health. Here he became a Methodist preacher and also wrote for newspapers. In 1870 he was made literary editor of the New York *Independent,* and afterward edited *Hearth and Home.* In this paper he published *The Hoosier Schoolmaster,* which related his experience in Indiana. Its popularity led to the production of other stories of the same kind, *The End of the World,* relating to the Millerite delusion; *The Circuit Rider,* to the experience of a Methodist minister; *The Graysons,* founded on an incident in President Lincoln's early career. But Eggleston began also a series of sketches of *Life in the Colonial Period.* The first volume was *The Beginners of a Nation* (1896), treating of the various experiments in colonization and the unexpected results of these ventures. These studies were more comprehensive than had been usual for historical purposes, and resulted in placing many of the eminent leaders in a strange light.

McMaster.—Of the later historians John Bach McMaster is the most eminent. He was born in Brooklyn in 1852 and graduated from the College of the City of New York in 1872. He became instructor in civil engineering in Princeton College in 1877, but after the publication of the first volume of his *History of the People of the United States* (1883) he was called to the University of Pennsylvania as professor of American history. The object of his great work, which is still in progress, is to present the social growth and material progress of the people as equally important with the political movements which have heretofore monopolized the consideration of historians. His first volume in general treatment recalled Green's *History of the English People,* while in style it resembled Macaulay's. But McMaster has gone on to develop both subject and style in a thoroughly original way. He objects to the hero-worship which has occupied too much space in the records of the past, but he seeks to do full justice to the leaders and their work. He regards the nation as truly a commonwealth, and the general welfare of the people as the essential element in its vitality. Besides his main work he has published *Benjamin Franklin as a Man of Letters* (1887) and *With the Fathers* (1896), a series of historical portraits.

Henry Adams.—The Adams family has long been prominent in public affairs. Its diaries and other records are an important source of information. Henry Adams, born in 1838, graduated from Harvard in 1858, and was private secretary to his father, Charles Francis Adams, who was American Minister to England during the Civil War. Afterward he was editor of the *North American Review* and professor of history at Harvard. He introduced new methods of study and inspired his pupils with enthusiasm for research. After writing excellent biographies of Albert Gallatin and John Randolph, he published his valuable *History of the United States, 1801-1817* (1889-1903). This comprises the administrations of Jefferson and Madison. In preparation of it Adams spent much time not only at Washington but at foreign capitals, examining the archives. The result is a complete reconstruction of the period, especially of the War of 1812. The history is characterized by orderly arrangement, clear style and well-authenticated statements.

Lodge.—Henry Cabot Lodge has been active in public service of his State and nation, and has also devoted much time to historical writing. Born in Boston in 1850, he graduated from Harvard and became editor of the *North American Review* and the *International Review.* He published *Life and Letters of George Cabot* (1877), in which he defended New England Federalists against the attacks frequently made upon their course, especially with regard to the Hartford Convention of 1814. He has written also briefer biographies of Alexander Hamilton, Daniel Webster and George Washington. His essays have been gathered in *Studies in History, Political and Historical Essays* and *Certain Accepted Histories.* He has also written a *History of the American Revolution.* He is a brilliant writer, but strongly partisan, even with regard to past controversies.

Mahan.—In the department of history no more epoch-making book has appeared in America than *The Influence of Sea Power Upon History* (1890), by Captain Alfred Thayer Mahan. Here for the first time was the prime importance and service of a navy adequately set forth in a history. While it discussed only the course of events from 1660 to 1783 the result altered the aspect of much more of the past and had direct effect on the condition of the present in every civilized country. He applied a philosophy to what had heretofore been dull, well-meant but almost unintelligent routine. Captain Mahan was born in New York City in 1840, and entered the Naval Academy at Annapolis at the age of sixteen. He served in the blockading squadron in the Civil War, and became captain in 1872. He was made president of the Naval War College at Newport in 1886. His duties there led to his preparation of his great work. This subject was continued in his *Influence of Sea Power Upon the French Revolution and Empire.* His biographies of Admiral Farragut and Lord Nelson have won the highest praise. His ideas on his special subject have also been directly applied in *The Interest of America in Sea Power, Present and Future.* The whole world has been converted to his central idea.

Roosevelt.—No previous President of the United States has contributed so much to historical and general literature as Theodore Roosevelt. Born in New York City in 1858, he graduated at Harvard in 1880, and in the next year was elected to the New York Legislature. It is not necessary here to summarize his various services to his city, State and nation until he was raised to the Presidency, first by the untimely death of his predecessor, and again by an overwhelming majority in the election of 1904. During his political career he spent his summers on a Western ranch, and was an ardent hunter of big game. He was also a diligent writer. Among his historical publications are *History of the Naval War of 1812, History of New York City* and *Winning the West.* With these may be joined biographies of Thomas H. Benton and Gouverneur Morris. Of books relating to his Western life there are *Hunting Trips of a Ranchman, Ranch Life and the Hunting Trail* and *Hunting Big Game.* Throughout his political career he was distinguished for devotion to principle and courageous independence. His thoroughly American spirit is as conspicuous in his writings as in his public life. His style is straightforward, vigorous and manly. His works hold an honorable place among American histories.

Stedman.—American literature has been benefited by the various collections, as well as the able criticisms and original poems of Edmund Clarence Stedman. Born at Hartford, Connecticut, in 1833, he was educated at Yale College, but was suspended for some frolic. For twelve years he was a reporter in New York and army correspondent. In 1864 he became a broker, but still did literary work. His poems were collected in 1884, and another volume was added in 1897. His *Victorian Poets* (1875) and *The Poets of America* (1880) are admirable for their just and discriminating criticisms. His own poems are chiefly lyrical, dealing with events of the time. Among them are *How Old Brown Took Harper's Ferry, The Hand of Lincoln* and *Pan in Wall Street.* Yale pardoned the poet and gave him a degree, and he honored her with a noble ode at her one hundred and fiftieth anniversary.

Aldrich.—As a poet Thomas Bailey Aldrich is delicate and polished, yet strong. In prose he has written excellent criticism, but is especially noted for quaint stories of quiet humor. He was born at Portsmouth, New Hampshire, in 1837, and was early employed in business in New York. But his inclination was to literature, and in 1866 he went to Boston to edit *Every Saturday.* His tour in Europe was described in *From Ponkapog to Pesth* (1876). In 1881 he became editor of the *Atlantic Monthly.* His poem, *Babie Bell,* relates the birth and short life of a child. He has used blank verse with good effect in *Judith, Wyndham Towers* and *The Unguarded Gates,* the last being aimed at the need of restriction in immigration to America. In stories, such as *Marjorie Daw,* he indulges in elaborate mystification. His *Story of a Bad Boy* recalls his own youthful pranks in a way to endear him to everybody. The longer novels, *Prudence Palfrey* and *The Queen of Sheba* are serious, yet not devoid of humor.

Stockton.—A curious talent is displayed in the humorous stories of Frank Richard Stockton (1834-1903). Odd, absurd and impossible events are related in a calm, straightforward manner, without any indication that they are out of the way. He was born in Philadelphia, and learned wood-engraving. He began his literary career by writing tales for children. His *Rudder Grange* (1879) first showed his talent as a humorist. His little story, *The Lady or the Tiger,* leads up to a thrilling situation, which the author leaves unsolved for the perplexity of his readers. Some of his romantic stories are continued with equally whimsical sequels.

Lew Wallace.—After winning fair fame as a general in the Civil War, Lewis Wallace gained international renown by *Ben Hur,* a story of the life of Christ. He was born at Brookville, Indiana, in 1827, the son of one who had been governor of that State. From a lawyer's office he went to serve in the war against Mexico. Afterward, becoming a lawyer, he was elected to the State

Senate. In the Civil War he commanded with distinction in both East and West, and obtained the rank of major-general of volunteers. His story, *The Fair God* (1873), related to the Spanish conquest of Mexico. While governor of Arizona he wrote *Ben Hur* (1880), which has obtained wider circulation than any previous American book except *Uncle Tom's Cabin.* The reason is obvious, for it appeals to the religious as well as the literary tastes of the people. General Wallace had then never visited the East, but his experience in Mexico had given him sufficient knowledge, aided by his imagination, to depict its scenery. His vivid description of the chariot race stirred the imagination of the people. Afterward he drew from the apocryphal Gospels *The Boyhood of Christ,* and later, in *The Prince of India* (1893), treated the capture of Constantinople by the Turks in 1453. He had, in 1881, been sent as American Minister to Turkey, and thus had direct knowledge of the scene. General Wallace, after his return, lived at Crawfordsville. He died Feb. 15, 1905.

Page.—Virginia life before and during the Civil War has been described in the dialect stories of Thomas Nelson Page with masterly skill. *Marse Chan* appeared in 1884, and was soon followed by *Meh Lady* and other tales, told by an old negro who looked back with fond regret to the blessings of slavery. Page was born in 1854, and, after graduating at the University of Virginia, became a lawyer in Richmond. His boyhood is described in *Two Little Confederates.* Besides writing various stories of the Civil War he has treated the period of reconstruction in *Red Rock.*

Julian Hawthorne.—The son of Nathaniel Hawthorne is a prominent journalist and novelist. He was born in Boston in 1846, and went with his father to England in 1853. He returned for his education, but left Harvard on the death of his father and went to Germany. He became a civil engineer and was employed in New York City. In 1872 he became a journalist, and has constantly written for periodicals. His *Saxon Studies* are pleasant and humorous sketches of German life. Among his best stories are *Bressant* and *Archibald Malmaison;* among the longer novels, *Garth* and *Fortune's Fool.* He has written a biography of *Nathaniel Hawthorne and His Wife,* and edited various books. He is a clear, fluent writer, yet with a fondness for mysticism.

Crawford.—Though born in Italy and graduating from Cambridge University, England, Francis Marion Crawford is claimed as an American. He is the son of the sculptor, Thomas Crawford, who moulded the statue of Liberty for the dome of the Capitol at Washington. He was born in 1854 and traveled widely, being for a time connected with a newspaper at Allahabad, India. From his experience there came his first novel, *Mr. Isaacs,* in which an educated Mohammedan pays court to a typical English girl. He has since been a prolific novelist, producing numerous brilliant stories of Roman and Sicilian life. Some of these form a connected series, as the trilogy, *Saracinesca, Sant' Ilario* and *Don Orsino.* Rural English scenery is found in *A Tale of a Lonely Parish.* Crawford has dealt also with life in New York, and has ventured to times as remote as those of the Persian king, Darius. In all he displays the same freedom of touch and ability to present lifelike characters. His *Ave Roma Immortalis* is a magnificent tribute to the glory of the Eternal City.

Women Writers.—The host of female writers in American literature has become so great that it is difficult to record them and almost impossible to assign their proper rank. There may be mentioned Elizabeth Stuart Phelps Ward, whose *Gates Ajar* (1868) won popularity and was followed by other books attempting to depict the future world, as well as stories about women's condition in the present life.

Mrs. Frances Hodgson Burnett, of English birth, wrote a powerful novel of English mining life, *That Lass o' Lowrie's* (1877), and afterward won greater popularity by *Little Lord Fauntleroy* (1887). She sketched Washington society in *Through One Administration* (1883), and in later books took up themes from English life of the eighteenth century.

Under the pen-name Octave Thanet, Miss Alice French, a native of Massachusetts, has sketched Western life, especially in Arkansas and Iowa.

Sarah Orne Jewett, born in Maine, has written many short stories of New England life. Her chief novel is *A Country Doctor.*

Mary Eleanor Wilkins Freeman has sketched the humble country folk, and especially the old maids, of New England.

Annie Trumbull Slosson has given special attention to the queer "cracked" characters who are still found in practical New England. Fishin' Jimmy, in *Seven Dreamers,* is one of the best.

Sarah Pratt McLean Greene went too far in her *Cape Cod Folks* by retaining the very names of the queer people she portrayed, and was compelled by legal process to alter her book. She has since written other sketches just as good.

Frances C. Tiernan, under the pen-name Christian Reid, has written *The Land of the Sky,* treating of western North Carolina, in which she was born. Other stories relate to Southern life.

Mrs. Frances Courtenay Baylor Barnum, born in Arkansas, has written of Virginia life in *Behind the Blue Ridge,* and an international novel, *On Both Sides.*

Mrs. Burton Harrison, whose maiden name was Constance Cary, is a descendant of Lord Fairfax, of Virginia. She resides in New York, and has described its fashionable society in *The Anglomaniacs* (1889). In other books she has used material gathered in her travels abroad. In *A Son of the Old Dominion* (1897) she pictures the South before the Civil War.

E. E. Hale.—While prominent as a Unitarian minister, Edward Everett Hale is more widely known as the writer of stories with a religious or moral purpose. He was born at Boston in 1822, where his father conducted a leading newspaper. After graduating at Harvard he became pastor of a church at Worcester in 1846. Ten years later he was called to the South Church, Boston. As a promoter of philanthropy he has organized numerous societies and made practical suggestions by means of stories as well as in other ways. To this class belong *Ten Times One is Ten* and *In His Name.* He has shown power to make that which is impossible appear reasonable and even actual fact. This is markedly the case with his famous story, *The Man Without a Country* (1863), written during the Civil War to inculcate patriotism. To it, afterward, he attached a longer story, *Philip Nolan's Friends,* a strange blending of fact with fiction which seems more true than fact. He was the originator and editor of *Old and New,* a monthly afterward absorbed in *Scribner's Magazine.* He also edited *Lend a Hand,* in the interest of charity organization. In his scores of books and hundred of sketches he has treated travels, politics, philanthropy, religion, biography and, finally, autobiography, all with the same unfailing, earnest, altruistic spirit. In 1903 this industrious and now venerable minister was made chaplain of the United States Senate.

Warner.—With wide experience of life and travel, Charles Dudley Warner (1829-1904) was an accomplished essayist and editor. Born at Plainfield, Massachusetts, he graduated from Hamilton College, went to Missouri as a surveyor, and became a lawyer in Chicago. In 1860 he settled in Hartford, Connecticut, as editor of the *Courant,* and in 1884 took charge of a department in *Harper's Magazine.* His humorous talent was made known by *My Summer in a Garden* (1870) and *Back Log Studies* (1872). His travels through the United States and to Egypt were related in delightful books. His favorite theme is shown in *The Relation of Literature to Life,* and his best biography is *Washington Irving.* Toward the end of his life he edited the excellent *Library of the World's Best Literature.*

Mark Twain.—The greatest humorist of America and, indeed, of the world is Samuel Langhorne Clemens, better known as Mark Twain. Born in 1835 at a village in Missouri, he passed from a common school to a printing office, and thence to a Mississippi steamboat to become a river pilot. His pseudonym comes from the frequent cry of the man with the sounding lead, "Mark twain," to indicate two fathoms' depth of water. The Civil War closed transportation on the great river, and Clemens in 1862 went to Nevada. After some experience of mining, he wrote sketches for newspapers, and became a journalist in San Francisco. His story, *The Jumping Frog of Calaveras County,* published by a friend at New York in 1867, struck the popular fancy. Still wider popularity came from his *Innocents Abroad,* a mirth-provoking report of a tourists' excursion to Europe and the Holy Land. When his vogue as a humorist was fully established he rehearsed his experiences on the Pacific Coast in *Roughing It.* He joined with Charles Dudley Warner in satirizing the modern race for riches in *The Gilded Age.* He settled in Hartford, Connecticut, and steadily poured forth droll sketches of Western life. *The Adventures of Tom Sawyer* and *Huckleberry Finn* are founded on his experience on and around the Mississippi. The latter is the most tragic story he produced. It shows a whole family, whose characters arouse lively interest, swept from the earth by a barbaric border feud.

These books, as well as lectures and contributions to periodicals, brought ample returns, but in an evil day Clemens ventured into book publishing. For a time the firm was highly successful, but eventually it became bankrupt. With cheerful courage and dauntless energy Clemens undertook to pay the debts and restore his fortunes by writing and lecturing. He went abroad and lectured in Australia and India with unfailing success. To his humorous sketches of American life he added a peculiar historical romance, *The Prince and the Pauper,* dealing with England in the sixteenth century. Then, in *A Yankee at King Arthur's Court,* he jumbled the present with the remote past in a ridiculous way. The story of Joan of Arc was treated seriously in a pretended narrative by a faithful attendant. This story, published anonymously, attracted little attention. The public whom he had entertained for years insisted on his remaining a droll humorist of national and local peculiarities. They did not relish his extravaganza of *Adam's Diary.* What they want is humorous pictures of the present day, such as he was wont to give in his prime.

Harris.—In the age in which folk-lore came into prominence, Joel Chandler Harris had the distinction of showing the literary possibilities of the negro fables. Born at Eatonton, Georgia, in 1848, he became a printer and journalist. While editing an Atlanta paper he prepared sketches of *Folk-lore of the Old Plantation.* Published in book form they created a literary sensation, and Uncle Remus, with his stories of the shrewdness of Br'er Rabbit, became a household favorite. Soon followed *Nights With Uncle Remus, Daddy Jake the Runaway* and other books and sketches of the same sort. Uncle Remus is but an idealized portrait of an old slave who told his fables to Harris in his boyhood. The author has published novels dealing with the Civil War and reconstruction in the South, but his fame rests on the simple fables.

Field.—In the works of Eugene Field (1850-1895) there is a curious mixture of the wild and breezy West with the rich and cultured East, of the boisterous cowboy with innocent childhood. Field was born in St. Louis, Missouri, of New England parentage. But being left an orphan, he was brought up by an aunt in Massachusetts. He attended Williams College in that State, and afterwards Knox College, Illinois, and graduated from the University of Michigan. After a year of travel in Europe he became a journalist in St. Louis, then drifted to Kansas City and Denver. Apart from routine and comical work he published stories of prairie life and poems in Western dialect. His marriage had a wholesome chastening effect on his literary work. He was called to Chicago and there filled a column in a newspaper with his *Sharps and Flats,* in prose and poetry. He was an indefatigable collector of books and curios and especially children's toys, dolls and drums. For children he wrote *Wynken, Blynken and Nod* and other charming poems. His lullabies have been set to music by several composers. He had fine classical taste and with his brother published free translations from Horace in *Echoes from a Sabine Farm.* His last book was *The Love Affairs of a Bibliomaniac.* This brilliant journalist has been well characterized as an American revival of the ideal jester of chivalric times, but he was still more a gallant Western troubadour.

Will Carleton.—Popular and moral, giving expression to the common feelings of humble people of town and country, are the *Farm Ballads* and *City Ballads* of Will Carleton. Born at Hudson, Michigan, in 1845, he graduated at Hillsdale College and wrote for Detroit and Chicago newspapers. The best known of his poems are *Betsy and I Are Out, How Betsy and I Made Up* and *Over the Hills to the Poorhouse.*

Riley.—In spite of his homely name, which he regarded as a serious handicap, James Whitcomb Riley has, by steady perseverance in his original way, reached even the high honor of a literary degree from the University of Pennsylvania. Born at Greenfield, Indiana, in 1852, he early showed a gift for rhyme, which was exercised in local papers. For a time he was connected with a band of strolling actors, for whom he recast plays and improved songs. Then he became a journalist and lecturer. Most of his poems are in the Hoosier dialect, as *The Ole Swimmin' Hole and 'Leven More Poems, Pipes o' Pan at Zekesbury, Rhymes of Childhood* and *Poems Here at Home.* Riley has touched the hearts of the people with his unaffected sentiment.

Vandyke. — Prominent in the Presbyterian Church as a scholarly preacher and in literature as a poet and an exponent of Tennyson is Henry Vandyke. He was born in Philadelphia in 1852, the son of Rev. Dr. Henry J. Vandyke, a Presbyterian minister who became more noted as pastor in Brooklyn. The son graduated at Princeton in 1873, and at its Theological Seminary in 1877. He studied also at Berlin, and on his return to America became pastor of a Congregationalist Church at Newport, Rhode Island. Thence he was called to the pastorate of the Brick Church in New York. He was also a Harvard preacher in 1890-92, and delivered the Lyman Beecher lectures at Yale in 1895. The exquisite finish of his sermons and his direct contributions to criticism and pure literature procured for him the professorship of English literature at Princeton University in 1900. For its 150th anniversary he gave the poem. Among his sermons and other religious writings are *The Reality of Religion, The Story of the Psalms, The Gospel for an Age of Doubt,* which was afterward supplemented by *The Gospel for an Age of Sin.* He has written also *The Christ-Child in Art,* and *The Poetry of Tennyson.* His essays and short stories comprise *The Ruling Passion, Fisherman's Luck,* and *The Blue Flower.* In *Little Rivers* he described his fishing excursions in picturesque places. His *Builders and Other Poems* contain exquisite verse, showing his love of nature and genuine imagination. *Music* (1904) is a similar collection of choice poetry—odes, legends and lyrics.

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The

Primary Mechanical Powers

HOW MAN'S GENIUS and METHODS TURN NATURE'S ENERGY TO PRACTICAL ACCOUNT

The Laws and Rules of Applying the
Natural Forces to Human Mechanism

AN INVALUABLE PARTNER FOR ALL WHO WOULD KNOW THE ELEMENTARY POWERS AND THE PRINCIPLES THAT OPERATE TO MAKE THEM AVAILABLE FOR MAN'S USE IN EVERY DEPARTMENT OF HANDICRAFT AND INVENTION :: :: :: :: :: ::

By J. M. DAVIS, Ph. D., LL.B.
Editor and Publisher of ENGINEERING-MECHANICS

Learning From The Infinite

PRACTICAL APPLICATION OF THE PRIMARY POWERS

SOURCES OF ENERGY

Strength of Men and Animals
Weight of Liquids
Motion of Liquids
Steam
Air, Wind, Water
Gas,
Chemical Action
Electricity and Magnetism

CLASSIFICATION OF MACHINES

Kinds, principles and uses in all mechanical branches

DIVISION OF PRIMARY MECHANICAL POWERS

THE LEVER, principle and place in mechanics; WHEEL AND AXLE, description and uses; THE PULLEY, power transmission of; INCLINED PLANE, rules of use; THE WEDGE, principle of power; THE SCREW, description of.

AUXILIARY STUDIES TO PRIMARY POWERS

Friction, Hydrostatics, Hydraulics, Pneumatics, Acoustics, Vibration, Heat Laws, Steam Engines, Optics, Strength of Materials, Chemistry, Electricity.

A Volume Which Makes Plain and Practical the Fundamental Things Every Mechanic Seeks to Know

The Primary Mechanical Powers.

What They Are and How They Are Applied in Doing Work—How a Mechanic Makes His Practical Calculations.

Object.—The purpose of the following introductory article on the Primary Mechanical Powers and their applications through mechanism is, as far as possible, to indicate in what way the fundamental powers and agencies in nature operate in and apply to each industry noticed. The application is necessarily general, but with a careful reading of the principles set forth and the aid of the illustrations, the reader will be better qualified to recognize the underlying principles which connect all trades and all systems which go to make up the great field of mechanism and mechanical activity.

Needs of the Day.—The urgent need of to-day is, especially in the mechanical world, not only the elucidation of elementary principles, but the gathering together within the most limited space possible, the leading principles, systems, methods and rules adopted by progressive mechanics and engineers, as well as by those great minds which have arisen in the world, to unite and concentrate and systematize within the most limited space for effective work, the great agencies in nature.

The Great Trinity of Forces.—Steam, electricity and chemical agencies may be termed the great trinity of forces, the knowledge of which will enable the mechanic to better understand his work. They will enable him to approach the great problems of to-day with more confidence and to acquaint himself with many of the inner workings of the laws upon which these great agencies are based, in a manner and to a degree which will lighten his toil, stimulate his interest and make him feel that he is an important part and parcel of the great systems of organized energy which are transforming the world and making it a reservoir of facilities, the use of which will bring to him more bread for his toil and enable him to take a higher step into the great family of thinkers and intelligent workers who have done so much to inaugurate the era of progress which is producing such rich fruits for the benefit of humanity.

Sources of Energy.

Sources of energy may be enumerated conveniently as follows:

1. Strength of men and animals.
2. Weight of liquids.
3. Motion of liquids.
4. Steam.
5. Air—wind—water.
6. Gas.
7. Chemical action.
8. Electricity and magnetism (for transmitting power).

Classification of Machines.—Machines may be classified for convenience as follows:

1. Machines for lifting or lowering solid weights, such as capstans, cranes and windlasses.

2. Machines for horizontal transport, such as all kinds of locomotives and propelling machinery.

3. Machines for projecting solids—artillery.

4. Machines for lifting fluids—hydrostatics.

5. Machines for propelling and projecting fluids—hydromechanics.

6. Machines for dividing bodies—digging, cutting, sawing, grinding, tearing, crushing, pounding, pressing out fluids as applied to earth, stones, metals, timber, fruits, grains, fibers or other materials.

7. Machines for shaping bodies by removing portions of them, which include machines for cutting, grinding, polishing stone, shaping pieces of metal or other material, whether by turning, boring, punching, slotting or gouging; by screw cutting, planing, by grinding and polishing to produce curved or plane surfaces.

8. Machines for shaping bodies by pressure, as used in rolling mills, in steam hammers, wire-drawing machines, pin making, coining and stamping machinery, brick-making machines and presses for packing and compressing.

9. Machines for uniting bodies into fabrics, as spinning and weaving machinery, paper making,

felting and sewing machinery, printing on paper, cloth or other material.

10. Machines for producing sound, as acoustics and music.

To this may be added various machines used in preparing textile fabrics.

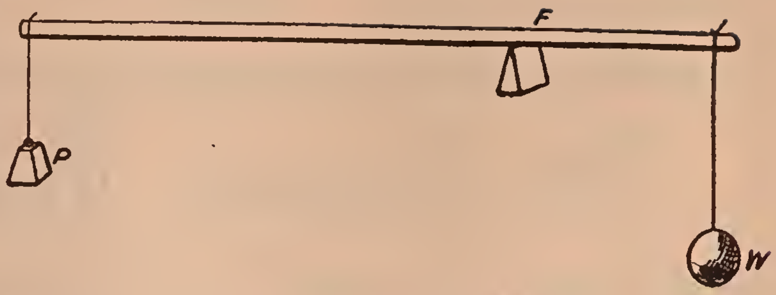
Power and Motion.

All the features of applied mechanics, hereinafter described, are based on certain primary principles or laws, whose practical application in the shop or factory leads to all manner and kinds of production. In nature, any action between bodies which changes, or tends to change their conditions is called force. Thus, we speak of the force of gravity, the centrifugal force, etc. Natural force makes itself clear to the senses of man through its motion or movement; and so we speak of the motion of light, heat, sound, etc. But when we come to speak of force in a commonly applied sense — that is, as force producing motion or pressure — we must begin to regard it as a mechanical agent, or as an agent from which useful mechanical energy is derived. In this sense we drop the word force and adopt in its stead the word power, which word at once strikes the mechanical ear as familiar, and he begins to talk about and to compute the effects of horse-power, water-power, steam-power, hand-power, the power applied at one end of a lever to lift a weight at the other end, etc.

The Mechanical Powers.—In mechanics, even of the most complicated kind, the powers employed are, for the most part, reduced to six in number, and are called the mechanical powers. They are the lever, wheel and axle, inclined plane, screw, wedge and pulley. Strictly speaking, the wheel and axle are only modifications of the lever. Machines, in all their varieties, are only combinations, to a greater or less extent, of the elementary principles embraced in these six mechanical powers.

The Lever.

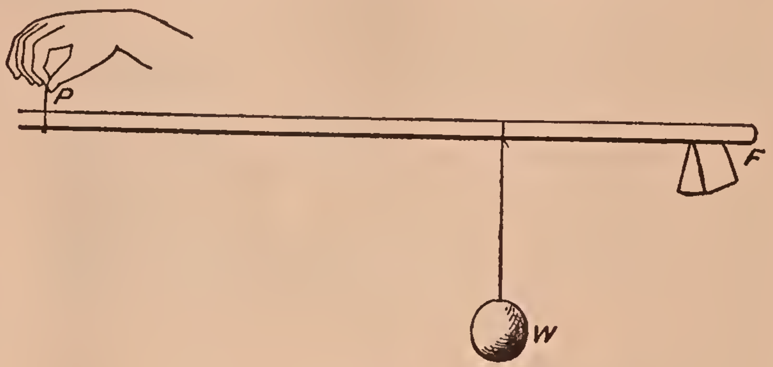
Definition.—In mechanics, a lever is any rigid piece which is capable of turning about one point or axis, called its fulcrum, in which are two or more other points where forces, or powers, are applied. In use, it transmits and modifies power and motion. It is usually named as the first of the six mechanical powers, and is of three kinds, according to the relative positions of the power (P), weight (W) and fulcrum (F):



Lever of the First Class.

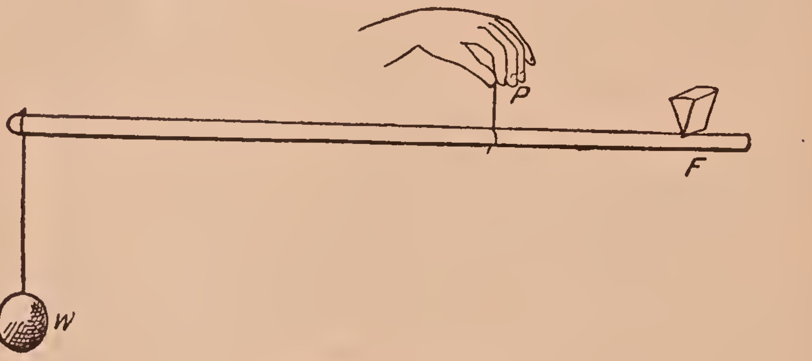
1. When the fulcrum (F) is between the weight (W) and the power (P), as in the common steelyard or ordinary pry.

2. When the fulcrum is at one end of the lever, with the weight between it and the power, as



Lever of the Second Class.

3. When the fulcrum is at one end of the lever, with the power between it and the weight, as



Lever of the Third Class.

The General Principle.—In all of these examples force is gained in proportion as the distance between the power and fulcrum exceeds the distance between the weight and the fulcrum. If the distances be the same, the power and weight will exactly balance. Or, to put it the other way, when the power is only half the weight, it must be at double the distance from the fulcrum. When the power is only one-third of the weight, it must be three times as far from the fulcrum; and so on. From which comes the general rule:

Practical Example.—To find the distance of any given power from the fulcrum, in order to balance a weight at a given distance from it, multiply the weight by the distance from the fulcrum, and divide the product by the power

Example: How far distant from the fulcrum must you place a weight of 120 lbs. in order to balance a weight of 500 lbs. at a distance of 5 feet from the fulcrum?

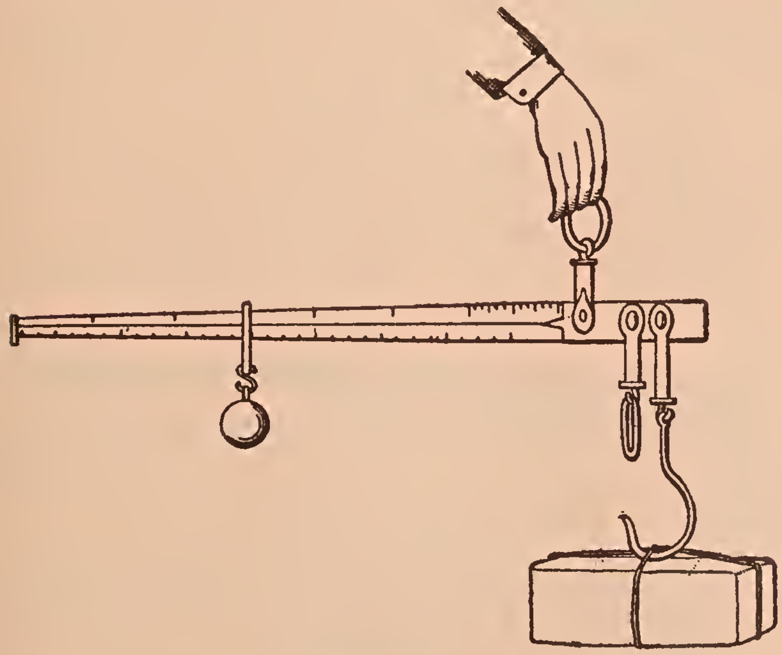
$$\text{Solution: } \frac{500 \times 5}{120} = \frac{2,500}{120} = 20\tfrac{5}{6} \text{ feet.}$$

Rule 2.—To find the power necessary to be applied at a given distance from the fulcrum to balance a given weight at a given distance from it, multiply the weight by the distance from fulcrum, and divide the product by the distance at which the power is to be applied.

Example: What power must you apply at a distance of 10 feet from the fulcrum to balance 100 lbs. at a distance of 2 feet from the fulcrum?

$$\text{Solution: } \frac{100 \times 2}{10} = \frac{200}{10} = 20 \text{ lbs.}$$

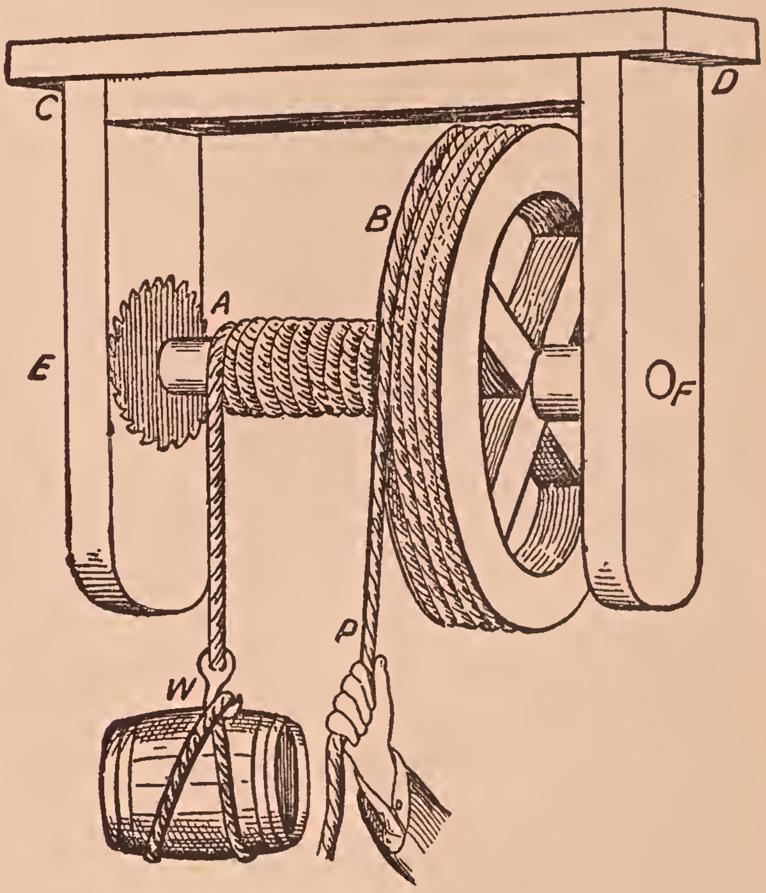
The Invariable Law.—However much we may vary the form of the particular example, the general principles of the lever, as stated above, do not vary, and fortunately they are very easy to understand. Even when several levers are combined so as to bring about a compound action, such action can be treated as the result of so many simple ones combined. As already stated, the common steelyard is the most familiar example of a lever of the first class. A lemon-squeezer or nut-cracker is a common illustration of a lever of the second class; while the legs and claws of birds and the limbs of animals afford examples of levers of the third class.



The Common Steelyard.

Wheel and Axle.

General Principle.—The wheel and axle, however its principle may be modified in practical mechanics, is never anything more nor less than an application of the lever of the compound variety. A familiar form of representing this mechanical power is thus:



The Wheel and Axle.

Description and Uses.—In this form the wheel and axle is used for lifting great weights (W) by applying the power (P) to the circumference of the wheel (B), and attaching the weight by means of a rope or chain to the circumference of the axle (A), the principle of equilibrium or balancing being precisely the same as in the lever, while the action is continuous. E and F are side supports and C, D a base for suspension. It is easy to perceive how many forms the principle of the wheel and axle may take—as, for instance, the power in the above cut may be applied at the end of the axle by means of a crank; or it may be applied at the circumference by means of water, as in water-wheels of different kinds; or it may be applied by means of horses, as in the common wagon; or in numerous other ways.

The Pulley.

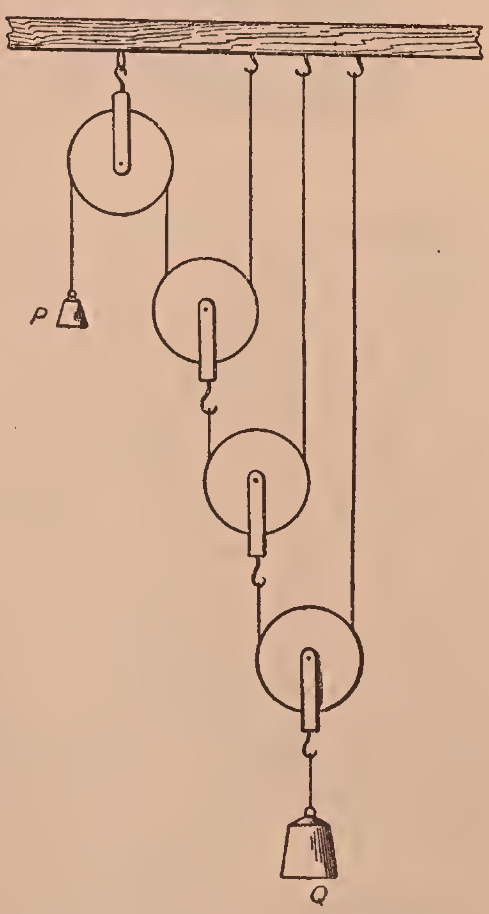
Description.—A pulley is a wheel with a plain broad or a grooved rim, for transmitting power from, or imparting power to, the different parts of machinery; or it may be used for simply changing the direction of motion, by means of a cord, belt, rope or chain. A single fixed pulley gives no increase of power, but only changes the direction of motion. Common forms of the pulley are thus represented:

Kinds.—Pulleys are movable and fixed. A fixed pulley revolves on its own axis without change of place. A movable pulley rises and falls with its weight. A movable pulley in its simplest form is a grooved wheel, called a sheave, turning within a movable frame, or block, by means of a cord or rope attached at one end to a fixed point.

At the free end of the cord the force or power acts. It is plain that the power is doubled, because half the weight of the object to be lifted is on the fixed end of the cord. While this is so, it is equally plain that the power thus doubled can lift the load only through half the space traveled by itself.

This is a beautiful illustration of the universal law of mechanics, that every appliance used for the increase of power does so at the expense of time; or, in brief, "What is gained in power is lost in time."

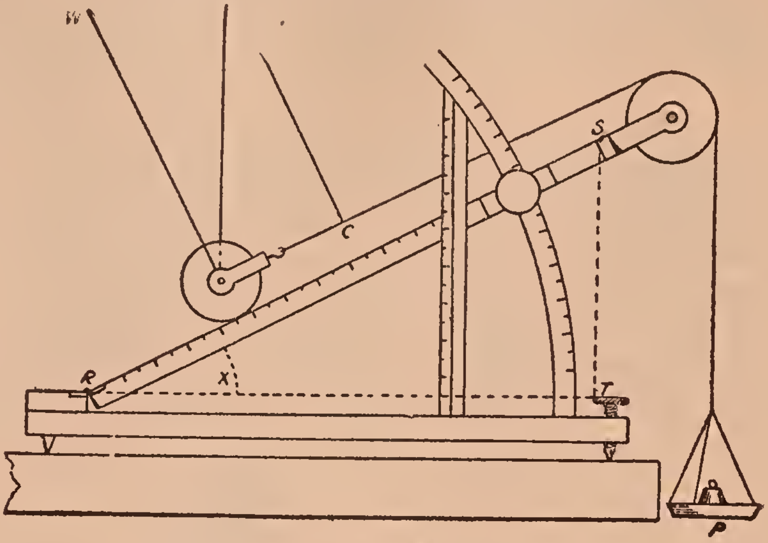
Rule and Example.—The principle of the pulley in the above simplest form need not be illustrated by any further example, but we can say in other language that any given power will balance double its weight. Therefore, if the power be known, you multiply it by 2 to find the weight it will balance; or, if the weight be known, you divide it by 2 to find the power required to balance it. So, if there be several pulleys, as in the adjoining cut, to find the weight a certain power will lift, or rather balance, you simply multiply that power by double the number of pulleys employed. Thus, if the power (P) be 100 pounds, and the number of pulleys be 3, you multiply 100 by 2 × 2 × 2 = 800 pounds, the amount of weight which 100 pounds will balance. When the weight is given and the power is asked for, you divide the given weight by twice the number of pulleys in operation. A tackle and fall or block and tackle is only several pulleys in a sheath.



Compound Pulleys.

Inclined Plane.

Description.—This is a plane that makes any angle less than a right angle with its base.



Inclined Plane.

Use and Rule.—As a mechanical power it is used to produce pressure or as a means of moving bodies. The rule as to the inclined plane is:

As power (P) is to weight (W), so is the height of the plane (T. S.) to its length (R. S.).

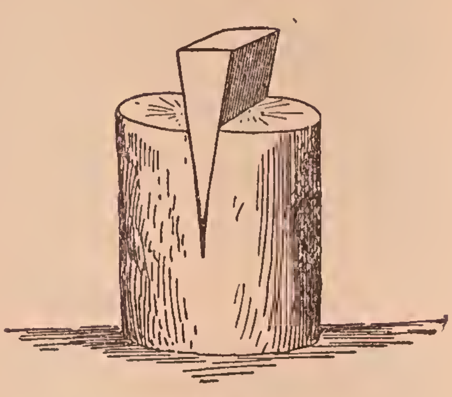
P : W : : T. S. : R. S.

This is a simple proportion, in which, if any three terms be given, the fourth can be readily ascertained. Or, to state it this way: If a plane be twice as long as its height, 1 pound acting over a pulley at P will balance 2 pounds anywhere along the plane. If the plane be three times the length of its height, 1 pound acting at P will balance 3 pounds anywhere along its length; and so on.

The Wedge.

Description.—The wedge is one of the six elementary machines called the mechanical powers. It is a piece of hard material, thick at one end and tapering to a thin edge at the other, used in the splitting of wood, rock, etc., and in the raising of heavy bodies.

Principle. — The wedge is nothing more than a modified inclined plane. It is generally made with its base perpendicular to a line drawn from the edge to the middle of the base. This means that it is made of two inclined planes placed base to base. The power is usually applied by the blow of a heavy body. The method of applying the power, and the peculiar character of the resistance to be overcome, make it difficult to give any fixed law for the wedge, but approximately the power (blow) is to the resistance (log) as the thickness or base of wedge is to length of wedge



The Wedge.

The Screw.

Description and Uses.—The screw consists of a cylinder of wood or metal, which is a thread, square or V-shaped. It is a modified inclined plane. The power is generally applied at the end of a lever, but it must be applied at some definite point to determine the law. The law of the screw cannot be determined unless the power is applied at some definite point on a lever. Lifting jacks, hay and cotton presses, screw propellers of ships, ventilators and air fans are familiar examples of practical uses to which the screw is put, besides the constant use that is made of it in machinery and wood working.

The Screw (Wood).

Further Description.—The screw may be further described as a central cylinder having a continuous rib or thread winding around it spirally at a constant inclination, so as to leave a continuous spiral groove between one turn and the next. As a mechanical power it is used as a threaded nail for fastening things together, but in a larger sense to produce, when revolved, motion or pressure in the direction of its axis, by the sliding of its threads in the grooves of a reversed screw adapted to it. In such case the revolved screw is called the male screw, and the reverse the female screw or nut.

Principle.—As a mechanical power, the screw is a modification of the inclined plane; for if you take any inclined plane or right-angled triangle, and conceive of it as being wrapped around a cylinder of wood or iron, the hypothenuse or inclined plane side of the triangle will correspond to the spiral thread of the screw, its base will equal the circumference of the cylinder, and its height will be the pitch of the thread. Therefore, the same form of proportion holds in the computation of power and weight as you find in connection with the inclined plane.

Rule.—To compute the power of the screw without lever, multiply the weight or resistance to be sustained by the pitch of the threads, and divide the product by the length of the plane which forms the screw thread.

The power of the screw with lever may be generally stated that its power is to the resistance in the same ratio as the pitch of the screw is to the circumference of the circle through which the lever or handle acts.

Take the pitch or distance between the threads, 1 inch, handle of screw, i. e., lever, 2 feet, the circumference of circle described by its extremity is $2 \times 2 \times 3.1416 = 12.57$ feet, or reduced to inches, 150.84; hence the ratio of power to weight is 1 to 150.84.

By exerting a force of 100 pounds at the end of the lever, the force exerted by the screw will be in the proportion, as 1 is to 150.84 so is 100 oz. to 15,084.00 pounds.

Friction.

Nature of Friction.—Friction is of two kinds—sliding and rolling. What is called the coefficient of friction is that fraction of the pressure which is required to overcome the friction. To compute the coefficient of the friction of bodies, place them upon a horizontal plane, attach a cord, and lead it in a direction parallel to the plane over a pulley, and suspend from it a scale to which weights are to be placed until the body moves.

How to Calculate.—The weight that moves the body is the numerator and the weight of the body moved is the denominator of a fraction which represents the coefficient required. If by a pressure of 480 pounds the friction amounts to 96 pounds, the coefficient of friction would be 96 divided by 480, which is .2 of the coefficient. If the coefficient of friction of a wagon over a sandy road were .2, and the load 9,000 pounds, the power required to draw it would be 9,000 multiplied by .2—namely, 1,800 pounds.

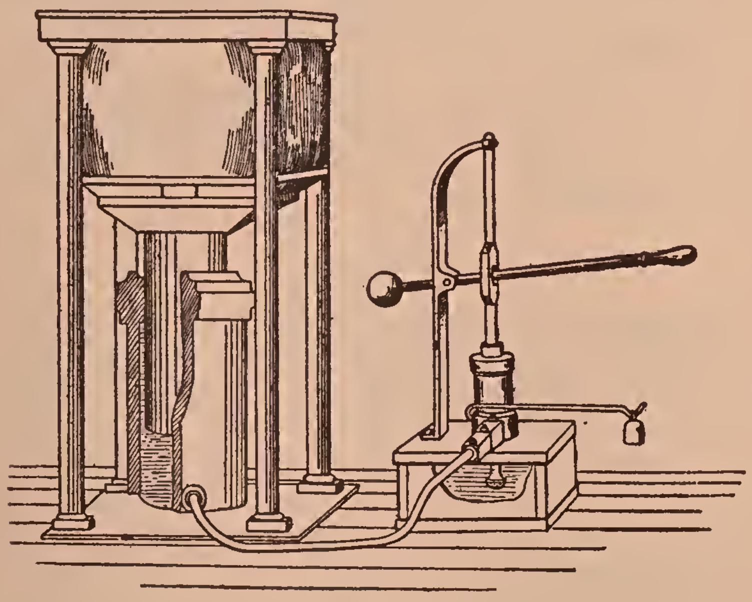
Hydrostatics.

Law of Hydrostatics.—The law of hydrostatics is that pressure exerted anywhere upon a mass of liquid transmitted undiminished in all directions acts with equal force on all equal surfaces and in a direction at right angles to those surfaces.

The pressure of the liquid upon the bottom of a vessel depends solely upon the area of the base of the vessel and the distance from the surface of the liquid.

Simple Rules of Calculation.—To find the pressure of the liquid upon the bottom of any vessel, multiply the area of the base by the depth of the liquid, and this result, in cubic feet, by the weight of a cubic foot of the liquid.

Hydrostatic Press.—A hydrostatic press is a pump with a small plunger, which forces the water into a cylinder, thus driving upward the large plunger which performs the required work. The principle is that any quantity of water, however small, may be made to counterbalance any weight, however great.



Hydrostatic Press.

To illustrate, take two cylinders of different diameters, connected by a tube having pistons whose areas are as 20 to 1. Let a weight of say 5 pounds be placed upon the smaller piston. This pressure will be conveyed to the larger piston with a force equal to twenty times that demanded on the small piston, or twenty times 5 = 100 pounds.

The theoretical velocity a liquid acquires in issuing from an aperture is found by multiplying the "head" or depth of the aperture below the surface by 64.4 and extracting the square root.

To find the pressure of a liquid upon the side of a vessel, multiply the area of the side by one-half its whole depth below the surface, and the product by the weight of a cubic foot of the liquid.

Hydraulics.

Law of Hydraulics.—The velocity of a liquid from an aperture inside of a vessel, of whatever shape, is equal to that which a body would require falling freely through a space equal to the depth at the middle of the aperture below the surface of the liquid.

Rules for Calculating.—To find the head, the velocity being given, square the velocity and divide by 64.4.

To find the volume discharged by drains, sluices, brooks and rivers of a given dimension in a given time, multiply the velocity of the current per second, in feet, by the area of the cross section of the current square feet, and the result will be the number of cubic feet discharged per second, which any mechanic with ordinary common-school education can readily solve.

If a vessel full of water be allowed to discharge itself, the quantity issuing from an aperture in any given time will be just half the amount which would be discharged in the same time if the vessel were kept full. Allowance must be made for friction in all cases.

Rules for Discharge from Reservoirs.—The discharges of fluids, in equal times, from the same apertures, from the same head, are nearly as the areas of the apertures.

The discharges of fluids, in equal times, by the same apertures, under different heads, are as the square root of the corresponding heights of the surface of the fluid above the apertures.

Facts Proven.—The discharge by a vertical tube is greater as its length is greater.

The discharge by an inclined pipe is greater than from a horizontal pipe.

The discharge of a fluid is inversely as the square root of its density.

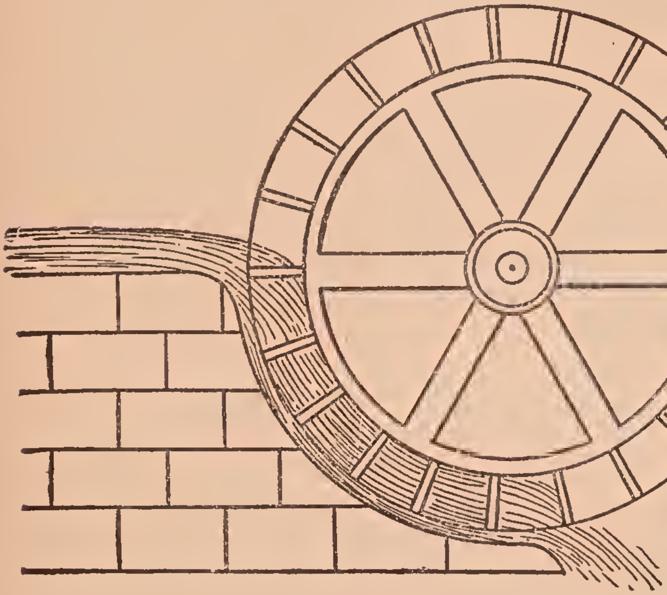
The velocity of efflux or discharge increases as the square root of the pressure on the surface of a fluid.

These rules at first sight may appear difficult of application, but a little effort will show their practical use.

Water Wheels.

Kinds of Wheels.—Water wheels are of four kinds—the undershot, the overshot, the breast wheels and the turbine wheels.

Rule for Computing.—To compute the power of an overshot wheel, multiply the weight of water in pounds discharged upon the wheel in one minute by the height or distance in feet from the center of the opening in the gate to the surface of the tail race, and divide the product by 33,000, which is one horse-power, and multiply the quotient by the assumed or determined ratio of the effect to power, which is usually .75; or, for general purposes, divide the product by 50,000, and the quotient is the horse-power.



Breast Wheel.

To compute the power of an undershot wheel, use 93,750 instead of 50,000, and .4 instead of .75.

Breast Wheel.—The mechanical effect of water is the product of its weight multiplied by the height of its fall. For instance, where the volume of water discharged upon an overshot wheel is 600 cubic feet per minute and the height of the fall is 20 feet, the point of the problem is to multiply 600 × 20 × 62.5, and divide by 33,000, which gives 22.73. Multiply this by .75, the assumed ratio of effective power, and we have as a result 17 horse-power.

Turbine Wheels.—The turbine is the most powerful and economical of all wheels, and acts horizontally. In high-pressure turbines the reservoir is closed at the top and the water is admitted at the sides. In low-pressure the water flows into the reservoir, which is open. The formula for computing the horse-power of a turbine is expressed:

$$.0425\,D^2h\sqrt{h}=p.$$

Example.—The diameter of a turbine is 8.3 feet, the fall of water 16 feet. What is the power?

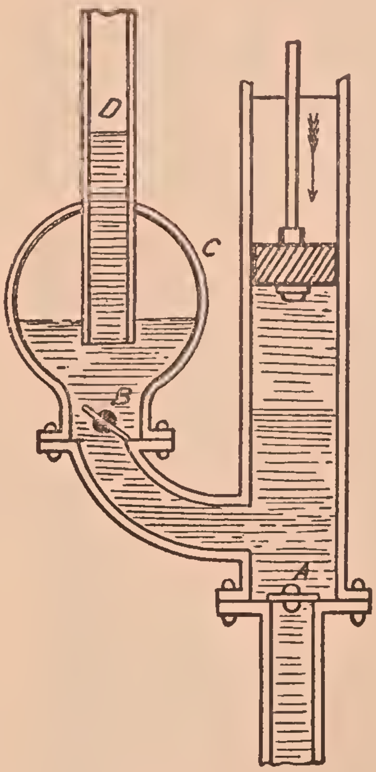
Rule.—Multiply the square of the diameter (8.3) by .0425, multiply the product by the fall of water (16), and multiply this product by the square root of 16 (which is 4). The product gives the horse-power.

Solution.—8.3 × 8.3 = 68.89 × .0425 = 2.927825 × 16 = 46.8452 × 4 = 187.38, the horse-power.

Pneumatics.

The Law of Gases.—The science of pneumatics treats of the properties of air and other gases, and of their motion and pressure. All gases are subject to the same laws. The law of compressibility of gases is that the volume of a given quantity of air, the temperature remaining the same, is inversely as the pressure upon it; that for a constant temperature the density and elasticity of air is directly as the pressure it sustained.

Example.—Thus, if a given volume of air occupies, respectively, the spaces, 1, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{100}$, the density and elasticity will be 1, 2, 4, 8, 100.



Force Pump.

Law of Absorption.—The law of absorption for the same gas, the same liquids and the same temperature, the weight of gas absorbed is proportional to its pressure; second, the quantity of gas which a liquid can dissolve is independent of the nature and quantity of other gases which it may already hold in solution.

As an illustration of the action of the laws of pneumatics, a suction pump is shown. In A is the base of a piston filled with water, to which force is applied. B is a valve opening into space C, and column D shows the height to which the water is raised under atmospheric pressure, in obedience to the force exerted.

Acoustics.

What is Sound?—Acoustics treat of the properties and laws of sound. Sound is the vibration of molecules of an elastic body when disturbed by any outside force.

Laws of Acoustics.—The intensity of sound will be inversely as the square of the distance of the ear from the vibration of the body.

The intensity will be increased as the amplitude of the waves is increased.

The intensity is in proportion to the density of the medium immediately surrounding the resonant body.

Intensity is modified by the condition of the atmosphere and by the direction of the wind.

The velocity of sound is dependent upon the temperature of the medium, and increases 13 inches for each degree above, and decreases 13 inches for each degree below 62 degrees Fahr.

At 62 degrees Fahr. the velocity of the sound is 1,120 feet per second.

The greater the elasticity of a medium, the greater will be the velocity of sound.

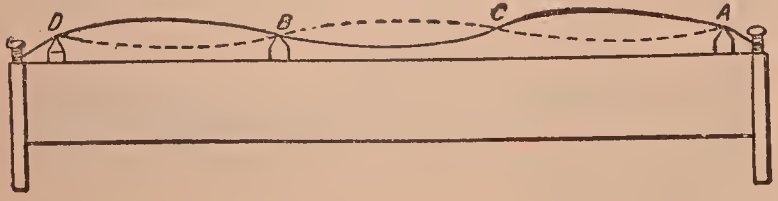
These general principles are readily applicable.

Vibration of Strings.

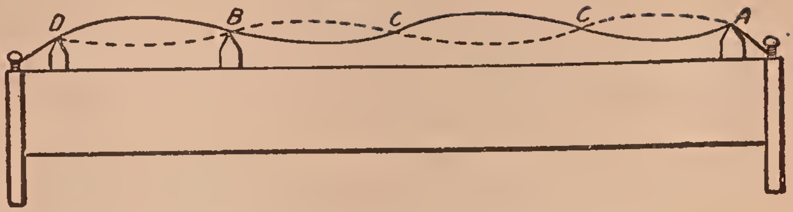
Law of Vibration.—Vibration of strings may be lengthwise or sidewise. The laws relate to the number of vibrations in a second, which is inversely proportional to their length; i. e., a string ½ foot long makes double the number of vibrations of one a foot long, and a string ¼ foot long four times the number, and so on.

Second Law.—A second law is, the number of vibrations in a second is inversely as the diameter of the string; i. e., if one string be twice the diameter of another, it will vibrate half as many times. Another law is, the number of vibrations in a second is directly as the square root of the stretching weight of the tension. That is, if a string produces a number of vibrations when stretched by a weight of 1 pound, it will require a stretching weight of 4 pounds to make double the number of vibrations.

The Bridge.—All parts of a string tend to vibrate in the same time. If a bridge is placed under the vibrating string, ⅓, ¼ or ⅛ the distance from the end, the remaining portion of the string will divide itself, in vibrating, into thirds, fourths and eighths, as shown in the following figures. The letters show the divisions of vibration.



Vibration in Thirds.



Vibration in Fourths.

Wind Instruments.—In wind instruments musical sounds are produced by the vibration of air confined within tubes. Where tubes are of equal diameter the pitch varies as the length of the vibrating column. Notes of different pitch are produced in the same instrument by joining tubes of different lengths and diameters, as in the organ. In reed pipes a simple elastic tongue sets the air in motion, and the tube is used to improve the quality and increase the volume of sound. The human organ of sound consists of a pipe, called the windpipe, and of the larynx and glottis. The vibration of the edges of these membranes caused by the passage of air, is like the vibration of reeds in pipes, and the sound thus produced is modified by the shape of the mouth and the action of the tongue and lips.

Laws of Heat or Pyronimics.

Sources of Heat.—Pyronimics relates to the laws of heat. The sources of heat are the sun, chemical action, electricity and mechanical action. Heat waves are as eternal as matter itself. Heat is simply universal motion or force, and is a concomitant of matter, and is a manifestation of motion in matter. Sound, light, heat, electricity, magnetism and chemical affinity are simply manifestations of motion, and each has its peculiar form of wave or undulation, and may be transformed into the other or directed so as to produce both. Fire is a union of undulations of heat and light.

Diffusion of Heat.—Heat is transmitted in three ways — by conduction, convexion and radiation. Different substances have different conductility. Taking silver as 100, copper has 73.6; gold, 52.2; iron, 11.9; steel, 11.6; lead, 8.5; platinum, 8.4. Taking the conductility of lead as 100, lath and plaster is represented by 26; asphaltum, 45; brick, 6; hair and lime, 109; pine wood, 28; plaster, 19; stone, 75. There are a number of laws connected with the diffusion and reflection of heat which are too intricate for ordinary application, but they may be briefly stated as follows: That radiation proceeds in all directions from a heated body; the intensity is proportional to the temperature of the source, and inversely as the square of the distance from the source; that is to say, taking the surface of a sphere 2 feet in diameter, which is four times that of a sphere 1 foot in diameter, the heat furnished a given space in a small sphere would have to be diffused over four times that space in the large sphere, hence could have only one-fourth intensity.

Reflecting Powers of Bodies.—Taking polished brass as the unit of reflecting power, silver is represented by 90; polished tin by 80; steel, 70; lead, 60; India ink, 13; glass, 10; lampblack, 0.

Water increases in bulk 1/22 when its temperature is raised from 32 degrees to 212 degrees Fahr. The greatest density of water is at 39.2 degrees Fahr. It expands until it reaches 32 degrees.

Points of Fusion of Various Bodies.—Ice melts at 32 degrees; lard, 95; pitch, 91; tallow, 97; tin, 421; zinc, 740; saltpetre, 600; steel, 2,500; lead, 594; cast iron, 2,100; wrought cast iron, 2,980; gold, 2,590; glass, 2,377; brass, 1,900.

Boiling Point of Various Substances.—Water boils at 212 degrees; linseed oil, 640; sulphur, 570; phosphorus, 554; oil of turpentine, 304; rectified petroleum, 316; sulphuric acid of the specific gravity of 1,848, 600; common salt, 226; nitric acid, 210; petroleum, 306; mercury, 662; coal tar, 325.

Mixture of Gases and Vapors.—The laws of mixture of gases and vapors are that the tension and quantity of vapor which saturate a space are the same for the same temperature, whether this space contains a gas or is a vacuum.

The tension of the mixture of a gas and a vapor is equal to the sum of the tensions which each would possess if occupying the same space alone.

Diffusion of Heat.

The diffusion of heat embodies a number of mechanical devices and adaptations which has built up one of the most important industries, having for its basis stoves and the methods of conveyance of heat from central sources.

Regarding slate as 100 in the conduction of heat, plaster is represented by 19; asphalt, 45; brick, 6; pine wood, 28; stone, 75.

The practical point in the diffusion of heat is its varying intensity from its origin. This diffusion is ascertained by a very simple law, which is that intensity is proportional to the temperature of the source—a most self-evident proposition—and, secondly, that intensity is inversely as the square of the distance from the source, as the accompanying diagram shows in the two circles between two diverging lines. S is the source of light. A is one foot or one yard distant, and shows the intensity in the square in the circle opposite. B is two feet or yards distant from the source, and is found by multiplying 2 by 2 = 4, as is proven by the four small squares in the larger circle opposite B.

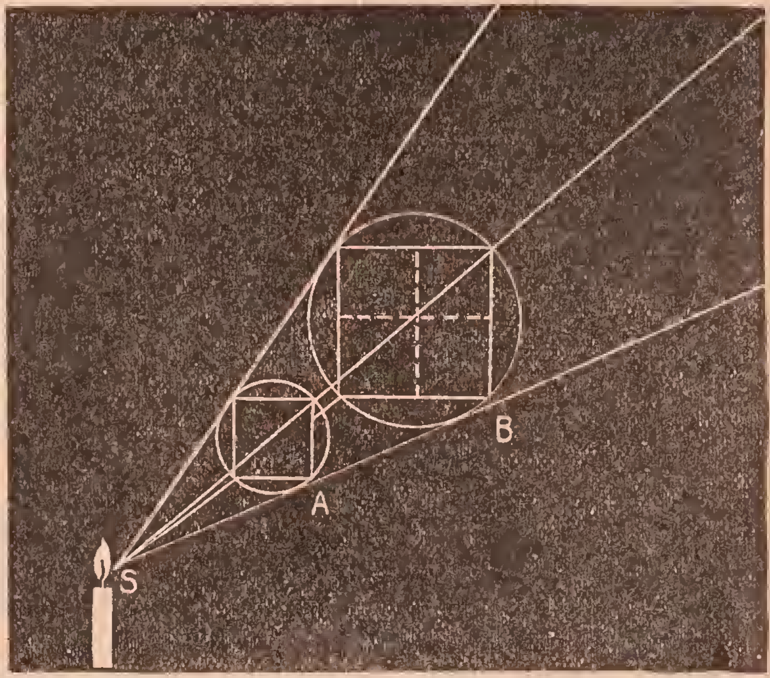


Illustration of Diffusion of Heat.

There is another simple fact and rule in nature, viz., that the angle of reflection is always equal to the angle of incidence, which is illustrated in the accompanying cut.

Place a ball (A) in the focus of a concave mirror (M), and a small quantity of an explosive (B) in the focus of mirror (N).

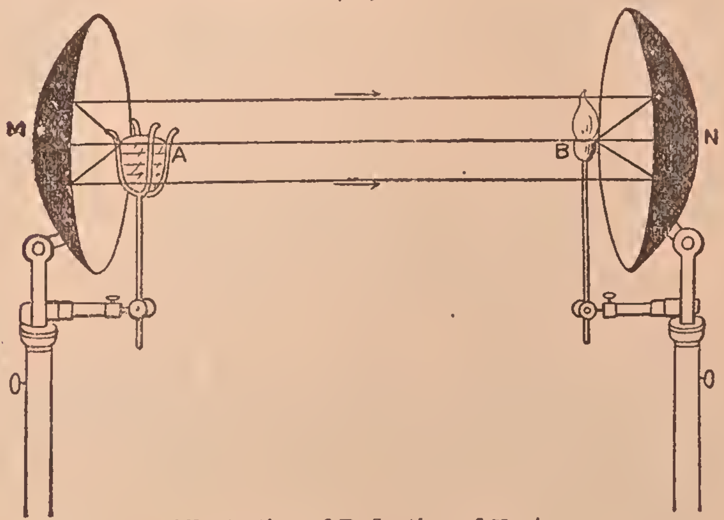


Illustration of Reflection of Heat.

The rays are reflected in straight lines from A to the concave surface of the mirror N, and are reflected to the explosive at B by the indicated lines, causing ignition.

Dark-colored substances absorb heat best; light-colored substances reflect heat best. Wool, being the poorest conductor, serves well as clothing; linen, being a good conductor, is less comfortable. Lampblack is the best known radiator.

Water forms an exception to the law of contraction of liquids. It contracts and increases in density to 39.2 degrees Fahr., then expands until 32 degrees is reached, which is a beneficent provision of nature, as otherwise the rivers would be frozen solid by the sinking of ice as formed.

The Steam Engine.

The Giant of Civilization.—The steam engine is the most wonderful mechanical agency in modern civilization, though its supremacy is being threatened by the only partially developed powers of electricity. To undertake to summarize all the powers and methods of the action of the steam engine would require the space of a large volume. That with which most mechanics are directly concerned is what the steam engine will do—i. e., its horse-power.

Horse-Power of Engines.—Horse-power is arrived at in the following way: Let HP represent horse-power; P, mean pressure of steam on piston-head in pounds per square inch; L, length of stroke in feet; A, area of piston-head in square inches; N, number of strokes (twice the number of revolutions of the crank) per minute. We have this formula:

$$\frac{P \times L \times A \times N}{33{,}000}$$

The above factors being ascertained, the solution is a simple matter. In a given cylinder the mean pressure (P) of steam on piston-head is 100 pounds; length of stroke (L) 2 feet; area of piston-head (A) in square inches 201+; number of strokes (N), 80 (twice the number of revolutions of the crank per minute); hence,

$$\frac{100 \times 2 \times 201 \times 80}{33{,}000} = 97 \text{ HP, prox.}$$

The area (A) is arrived at by squaring the radius of the cylinder, $8 \times 8 = 64$, and multiplying by the times the circumference is greater than the diameter of cylinder, viz., 3.1416, i. e., $64 \times 3.1416 = 201 +$.

Again, in a given cylinder length of stroke is 4 feet; diameter of cylinder 32 inches; pressure 40 pounds; number of strokes 40 per minute.

Solution: Pressure, 40, by length of stroke, 4 feet, by area of cylinder, 804.25, by the number of strokes, 40, equals

$$40 \times 4 \times 804.25 \times 40 = 156 \text{ HP, prox.}$$

Connecting-Rod and Cranks.—The connecting-rod of a steam engine is usually made from 4 to 8 times the length of the crank—i. e., 2 to 4 times the length of the stroke of the steam cylinder.

Crank-shafts are subject to three stresses: one at the beginning of stroke, one at middle, and when a fly-wheel or paddle-wheel is attached, the shaft is deflected by the weight. Shafts are submitted to combined torsion and flexure, which have to be reckoned with.

The Steam Chest.—The dimensions of the steam chest usually consist of the two ends and two sides of a cast iron box, resting upon the rim surrounding the valve face, upon which a flat cover is placed, firmly secured to the steam cylinder. The sides and cover are of the same material and thickness as the cylinder walls.

No rule can be given for the thickness of the piston-head under all circumstances. The piston-rod is usually made of best steel; one end is fastened at the piston-head and the other keyed to the cross-head, and must have sufficient rigidity not to bend in the slightest degree while in action. In order not to weaken the piston-rod where it enters the piston-head, it is customary to thicken the rod.

The crank-pin is one of the most troublesome parts of the steam engine, and it is necessary to proportion it properly so as to prevent heating. The diameters are usually equal to their length. Various tables are worked out to guide the engineer in his calculations.

Reciprocating Parts.—The reciprocating parts of an engine are the piston-head, piston-rod and connecting-rod; and in a vertical engine, the working beam, if one is used. Keys are used to prevent the crank from slipping on the shaft. The best position is in line with and between the centers of the eye and the hub of the crank. The first requisite of the crank-shaft is rigidity. Shafts are subject to stress in flexure only, either when at rest or at the dead points, when no fly-wheel is used. For the purpose of obtaining greater regularity of revolution of the crank-shaft, as well as to enable the engine to start in any position, two cranks at right angles are frequently used. Triple cranks 120 degrees apart are sometimes used to attain still greater regularity of motion. Increasing the speed of the rim of a fly-wheel, or, what is the same thing, increasing its diameter and number of revolutions, one or both, is productive of economy in weight.

Foundation Work.—In the foundation and framework of engines every precaution must be taken to obtain rigidity and immovability. Too much stress cannot be laid on this point. A high speed is attended with the disadvantage of rapid wear. The points of a good engine are these: concentration of power, economy of steam, regularity of speed, simplicity of design and durability of construction. Wherever steam economy is the first consideration, four-port cylinders are used, and every possible means taken to prevent iron surfaces from being alternately exposed to higher and lower temperatures of steam. The jet condenser is the cheapest and most efficient, and should be used where the quality of water will permit. The surface condenser should only be used where it is necessary to separate the condensing water from the boiler feed water.

What is Here Shown.—It is not to be supposed that a description of all the functions and actions of the steam engine is herein presented. It is intended to indicate in a general way some of the more important parts and their relation to each other. The generation of steam and its passage to the cylinders in the performance of work, is outwardly a simple action, but the manner in which this work is most efficiently and economically done in the modern steam engine is the result of effort of a vast number of enthusiastic and expert mechanics and inventors.

Optics.

Theory of Light.—Optics treat of light and vision. The established theory is that light is only a kind of motion in matter not well understood. Light differs from heat only in the length or form and rapidity of material vibrations. Like heat waves, light passes without interference through some substances, but is diffracted, refracted, reflected or neutralized in others.

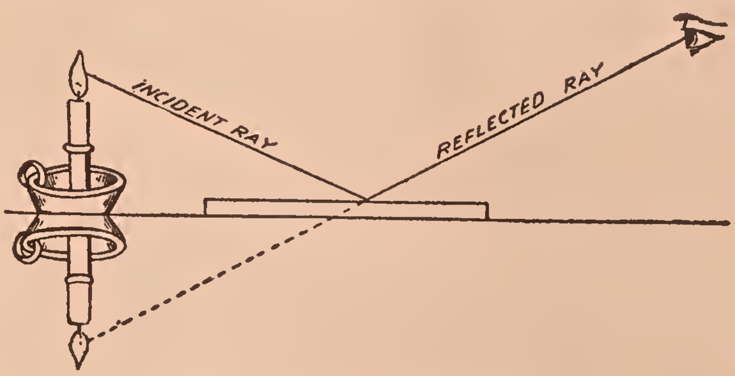
Lenses.—Lenses are of six kinds, viz.: double convex, plano-convex, concavo-convex, double concave, plano-concave and diverging concavo-convex. The first three thicken at the center to converge the rays; the other three thin at the center to cause a diverging of the rays. Convex lenses are called magnifying glasses or microscopes. Concave lenses remedy short-sightedness because of too great convexity of the lens of the eye; convex lenses correct defects of the eye due to the flattening of the lens of the eye.

Two Fundamental Laws.—The two fundamental laws in optics are, the law of direction, which gives the position of all points in space and explains the anomaly of erect vision with inverted retinal images; the other, the law of corresponding points, the second anomaly of vision, viz., single vision with two retinal images.

Adjustments.—There are two adjustments of the eye in every voluntary act of sight—focal and axial. The perception of objects is the result of the combination of two similar images.

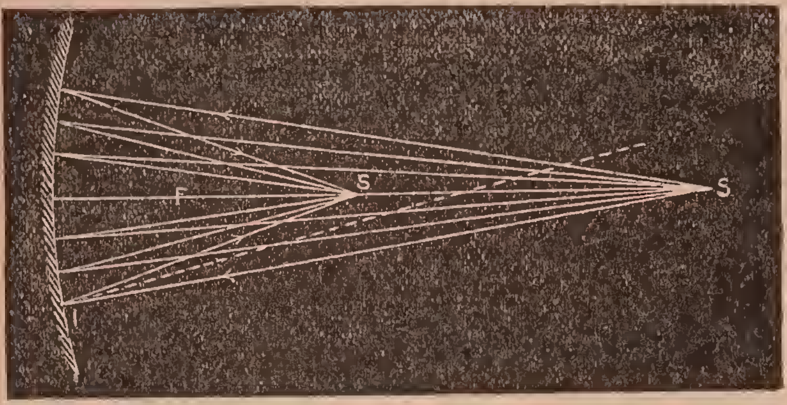
Velocity of Light.—The velocity of light is 186,000 miles per second. The law of intensity of light is: at any given distance it is inversely as the square of its distance from the source of light.

Images.—The representation of any object resulting from the reflecting rays of light is an image. Any image in a mirror will be as far behind the mirror as the object is in front, and in an inverted position, because the light from the parts of the object which are farthest from the glass make a greater angle with the plane of the glass and a less angle with its normal. This principle is herewith illustrated, in which the candle appears inverted.



Inverted Image in Plane Mirror.

Mirrors are concave or convex. Concave mirrors are sometimes called burning mirrors, since, if large, they reflect sufficient heat to the focus to set on fire combustible material. If a luminous body be placed at the center of curvature of a concave mirror, the rays will be reflected directly back to the point of emission, because they all strike the mirror perpendicularly. When the luminous body is placed beyond the center of curvature, the rays will converge to a point between the principal focus and the center, as shown on next page.



Light between Curvature and Focus.

In this illustration the light by being placed at S, beyond the center of curvature, converges to the point S′ between the source and the reflecting surface. The degree of convergence is determined by the nearness or remoteness of the light.

Strength of Materials.

In dealing with the strength of materials we have to consider the various properties, among which may be mentioned malleability, ductility, elasticity, tenacity, hardness and brittleness.

Hardness of Woods.—Shellbark hickory is the hardest wood among our forest trees, which may be called, for purposes of comparison, 100; next comes white oak, 84; white ash, 77; white hazel, 72; apple, 70; red oak, 69; white beech, 65; black walnut, 65; black birch, 62; rock maple, 56; white elm, 58; chestnut, 52; yellow poplar, 51; butternut, 43; white pine, 30.

Other Qualities.—We have also to do with such qualities as red shortness, which means that the steel is brittle when hot, due to sulphur; cold shortness, due to brittleness when cold, due to phosphorus; blistered steel, due to hammering; shear steel, made by holding up, heating and welding; and cast steel, made in molds.

Other considerations to be kept in mind are ultimate strength, which is a load necessary to produce fractures; proof of strength, the greatest safe load; dead load, one that is gradually put on; live load, one suddenly put on and accompanied by vibrations.

Modulus of Elasticity.—Many practical men are discouraged when they read the term modulus of elasticity, so frequently used in speaking of the strength of material. As it is very important to understand it, we will make it easily comprehended. It simply means the amount of weight in pounds, applied to the end of a bar, which would elongate it to the extent of its own length, provided the bar were perfectly elastic.

To Compute Modulus.—To compute the weight of a modulus of elasticity of a substance, the rule is, as the amount of the extension or compression of the length of a given substance is to its length in inches, so is the force or weight in pounds that produced such change, to the modulus of its elasticity in pounds.

Example.—Take an example. If a bar of iron 1 inch square and 10 feet long be increased in length .006 of an inch by a weight of 1,000 pounds, what would be its modulus of elasticity?

Solution.—Multiply the length in inches (120) by weight (1,000 pounds), and divide by .006, the quotient giving 20,000,000 pounds, or the modulus of elasticity.

To compute the height in feet of a modulus of elasticity, divide the weight of the modulus in pounds by the weight of 12 cubic inches of the material.

Practical Use of Modulus of Elasticity.—The strength and value of material is determined by and referred to its modulus of elasticity, therefore its importance. For instance, the modulus of elasticity of cast iron is 17,968,500, as determined by numerous tests; wrought iron, 25,820,000; wire, 28,230,500; cast copper, 18,240,000; oak, 1,710,000; white pine, 1,830,000.

Crushing Strength.—The crushing strength of cast iron ranges from 112,000 pounds per square inch to 175,000 pounds; machine brick, from 6,000 to 14,000 pounds; common brick, from 800 to 4,000 pounds; masonry, from 500 to 800 pounds; glass, 30,000 pounds; Italian marble, 12,000; American, 8,000.

Crushing Strength of Woods.—In woods the average crushing strength is: ash, 6,000 to 9,000 pounds; cedar, about 6,000 pounds; locust, 9,000; maple, 8,000; pitch pine, 9,000; white pine, 5,775; yellow pine, 8,200; walnut, 6,645; white hickory, 8,925; white oak, 6,000; spruce, 5,950.

The crushing strength of brass is about 165,000 pounds; copper, 117,000; steel, 295,000; lead, 7,730; limestone, 2,000 to 7,000; granite, 6,000 to 10,000; sandstone, 2,800 to 20,000.

Special Tests the Only Safe Rule.—In the limitations of this article it is impossible to more than indicate general principles of construction and resisting and crushing strengths. This general law or rule can be laid down: When it is desired to ascertain the dimensions and form of a girder or beam, when fixed at one end and loaded at the other, we must have regard to the product of the length, breadth, and square of the depth. Crushing strength is proportional to the area of section and inversely as the height. The value of all rules and tables, however, is largely uncertain, by reason of the unknown nature of materials used; therefore it has become customary in modern construction to apply specific tests to material used, or, in the case of iron and steel, to so control its manufacture that certain definite results can always be relied upon by builders and engineers.

Testing Machinery.—Testing machines and testing apparatus, therefore, have come into very general use. Mechanical engineering has developed to a high degree of not only theoretical, but practical utility, and all equipment of machinery and all material of construction are wisely passed upon by skillful engineers, who are quick to detect weakness and to determine the safe working capacity and endurance of all machinery and appliances and all material used in construction.

Torsional or Twisting Strength.—Hollow cylinders or shafts have greater torsional strength than solid ones containing the same volume of material.

The torsional strength of bars of like diameter is inversely as their length.

While these rules are correct, it is impossible to give definite rules for the torsional strength of materials which vary in size on account of the variations in the quality of castings.

Shafts.—Shafts of equal length have lateral stiffness as their breadth and the cube of their depth. They have lateral strength according to their breadth and the square of their depth. Their stiffness increases with the depth in greater proportion than their strength.

Lateral Stress Computations.—In order to compute the diameter of the shaft of cast iron to resist lateral stress only when the stress is in the middle, multiply the weight by the length of the shaft in feet, divide the product by 500, and the cube root of the quotient will be the diameter in inches.

To compute the diameter of a solid shaft of cast iron to resist its own weight only, multiply the cube of its length by .007, and the square root of the product will be the diameter in inches.

To compute the diameters of shafts of wrought iron, oak and pine, multiply the diameter obtained for such cast iron shafts by .935 for wrought iron and by 1.83 for oak, and by 1.17 for pine.

Chemistry.

Purpose of Chemistry.—The science of chemistry is an attractive, entertaining and exact science. It has opened up to the world a vast field in the development of which mighty industries are built up. Its language is the language of symbols. Its conversation is in proportions. Its music is that of organized nature, and its purpose is to cast a light on God's footsteps through the universe, from the atom to the Eternal Whole.

Elements.—Chemistry has to do with the union and separation of the ultimate atoms of matter according to the laws which hold them together or permit of their separation. There are some 75 elements in nature—i. e., states of matter which cannot be separated into anything else. Each atom has its own weight, and unites with other atoms in varying proportions. Recent investigations tend to cast a shadow over all the long-accepted conclusions of science and to create the presumption, at least, that those states of matter which are classed as elements are interchangeable and transmutable. Thus we turn our steps in the direction of the medieval alchemists who believed in the transmutation of matter, that the ultimate condition of matter will now constitute a question and a problem which will engage the enthusiastic study of the world's greatest investigators. Along the same line the nature of intelligence and thought are being investigated, and England's deepest and most renowned thinker and philosopher recently intimated that all the universe was one thought or convertible into one thought.

Simple Illustration.—When 21 atoms of oxygen unite with 79 atoms of nitrogen to form air—a certain association of hydrogen and oxygen to form water—the force which holds these atoms together is called affinity or chemism.

The union of elements is called synthesis; their separation, analysis.

Hydrogen the Basis.—All chemical calculations are based on the hydrogen atom, which is taken as a unit. For instance, one volume of oxygen is sixteen times as heavy as an equal volume of hydrogen.

The union of the elements with each other in their endless proportions constitutes the science of chemistry. These unions and disunions are all subject to numerous and apparently endless fixed laws, the operation of which fills countless "works" on chemistry.

Some Leading Elements.—Prominent among the elements with which the chemists and metallurgists have to do are carbon, calcium, copper, hydrogen, gold, iron, lead, mercury, nitrogen, oxygen, platinum, potassium, silicon, sodium, silver, sulphur, tin and zinc.

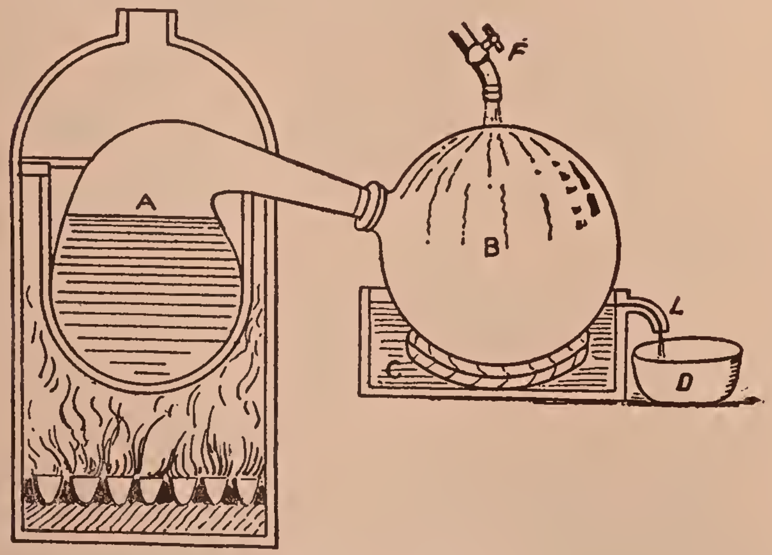
A Most Important Element.—Carbon is one of the most important elements in nature, and is on friendly terms with innumerable products. It is an important constituent in rock and deposits in the earth, as, for instance, coal, graphite, petroleum and asphalt, and is largely found in animal and vegetable tissue.

The elements are chiefly found in combination with other elements and matter, and it is the province of chemistry to separate them. Sodium, for instance, is found most abundantly in combination with the element chlorine, in the form of sodium chloride, which chemists indicate by NaCl, Na meaning sodium and Cl meaning chlorine, which is common salt.

Acids, Bases and Salts.—Next above the elements we have acids, bases and salts as their products. These products, in turn, are the foundation of other endless combinations of products of laboratory or commercial value. One compound of nitrogen and hydrogen is ammonia. Sulphur combines with hydrogen, iron, copper and numerous other products to produce acids.

How Acids are Formed.—Copper, acted upon by various acids, produces numerous valuable products. Silver combines with sulphur to produce its peculiar combination.

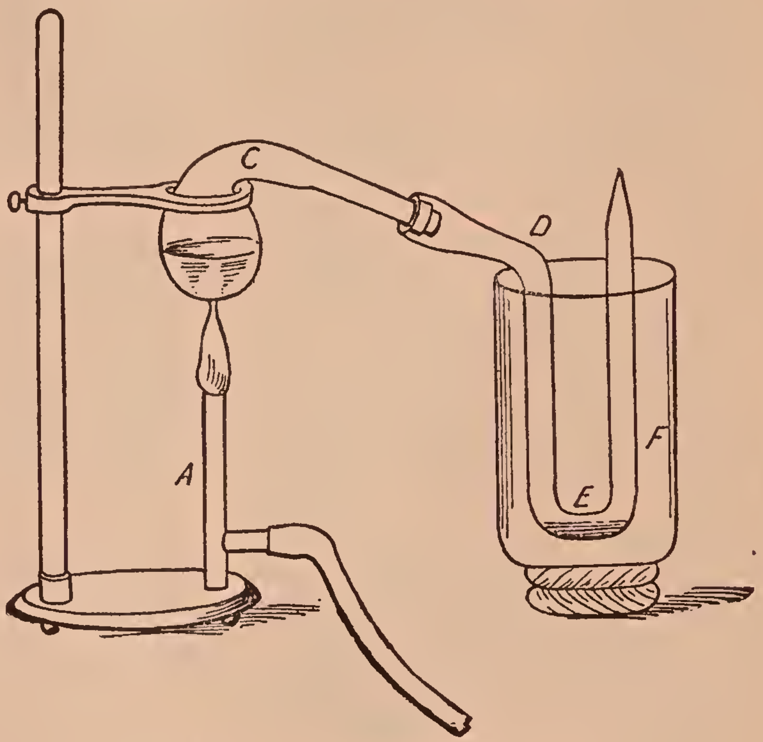
Organic acids produced from plants and animals are produced by the oxidation of alcohol, and forms endless acids for commercial uses. From these are formed acids, among which may be mentioned acetic, carbolic, carbonic, hydrochloric, nitric, prussic, sulphuric and tannic acids of commerce.



A Retort for Acid Making.

Utility of Chemistry.—No other science is so closely related to the industries as chemistry. Since 1850, over six thousand processes have been patented, all of them of greater or lesser value in the industries. No other science has as many original investigators, or produces as much in the way of invention and demonstration of the action of chemical forces for the good of man.

Illustration of Acid Making.—A retort showing a simple method for the preparation of acid. Sodium nitrate is heated in the retort (A) with sulphuric acid. The sodium is replaced by hydrogen, forming nitric acid. The acid passes over in form of vapor, and is condensed in the receiver (B) by the external application of cold water through the tube (F) to the network covering of the receiver in the trough (C). The product is received through the orifice (L) into the pan (D).



Apparatus for Making Hydrochloric Acid.

The above illustration shows how hydrochloric acid is obtained by heating common salt mixed with sulphuric acid. A is the flame striking receptacle, C, and D is a tube connecting the mouth of the retort with a receiver, F. The hydrochloric acid is condensed in the receiver at E.

The application of chemistry to the industries and into industrial agencies is becoming more and more productive of commercial advantages, and the growth of industries relying upon chemical methods and action is keeping pace with the purely mechanical industries.

Organic acids are produced by the oxidation of alcohols and frequently by fermentation. There are five combinations of oxygen with nitrogen. What are known as bases in chemistry consist of a metallic element with oxygen and hydrogen, the number of hydrogen and oxygen atoms usually being equal and their union in bases makes them regarded as a compound radical. When an acid and a base are brought together the hydrogen gets out, and what is termed a salt is formed. The salt is composed of the metal from the base and the non-metal and oxygen of the acid. Nitric acid, one of the most useful in the arts and industries, is the best solvent for metals. It is made of sodium nitrate (saltpetre) by the action of sulphuric acid. Sulphur forms a large number of compounds, its most important being sulphuric acid, and sets free most all acids from their salts. It is made by passing sulphur dioxide (from burning sulphur) into a chamber into which a jet of steam is introduced, in connection with a little nitric acid which oxidizes the sulphur dioxide when it combines with the water vapor, and we have sulphuric acid.

Phosphorus is prepared from animal bones and rock, which is treated with dilute sulphuric acid, which product is evaporated and is distilled into cold water. Silicon and oxygen always go together, forming silicates. Carbon is one of the most common and important elements in matter. Carbonic acid is a most valuable industrial agent. Ammonia is another valuable agent and forms salts. There are numerous compounds of ammonia, producing nitrates, sulphates and acid carbonates. Copper, mercury and silver form various compounds, mercury uniting with most metals to form alloys, termed amalgams.

The compounds of aluminum are various, and is an important constituent of clay, slate and granite rock. Lead forms three oxides; tin, two series of compounds. Benzine is important in its numerous commercial uses in various forms, viz., nitro-benzine, used to manufacture aniline dyes; picric acid, used to manufacture certain explosives, and in dyeing; tannic acid, creosote, carbolic acid and a long list of compounds used in medicines.

ELECTRICITY.

Its Principles and Mechanical Appliances.

Source of Electricity.—Electricity is simply a phenomenon of etheric wave motion, and is developed by friction, pressure, chemical action and by other familiar causes. "Potential" expresses degrees of electrical energy, after the manner of pressure in steam. Any substance through which the current flows is spoken of as a conductor. Electro-motive force (EMF) is that force which tends to move electricity from one point to another, and is proportional to the difference of potential of any two points.

Electrical Units.—The practical units in most frequent use are the volt, the ohm and the ampere. The volt, so named in honor of Volta, a distinguished Italian electrician, is the standard unit by which the electro-motive force is measured. Thus, we say, when speaking of such force or strength, it consists of 5 volts, 50 volts, 1,000 volts, etc. A single volt is the electro-motive force which produces a current of one ampere in a circuit which offers a resistance of one ohm. In actual strength it is about one-tenth less than the electro-motive force produced by a Daniells' sulphate of copper cell.

The ohm, so called from the German electrician, Ohm, is the unit by which is measured the amount of resistance offered to the passage of an electric current through a circuit; that is, it is the resistance of a circuit in which a potential difference of one volt produces a current of one ampere in strength.

Ampere, named in honor of the French electrician, Ampere, is the standard unit of current in electrical measurements. It is the current produced by an electro-motive force of one volt acting in a circuit having a resistance of one ohm. The ampere, therefore, or strength of current delivered is always equal to the electro-motive force (volt) divided by the resistance (ohm). Thus:

$$\frac{100 \text{ volts}}{5 \text{ ohms}} = 20 \text{ amperes of current.}$$

Resistance is inversely as the number of series of cells. Current is set up by the association of two differing metals immersed in an acid. The celebrated Ohm's law is that the strength or intensity of an electrical current is directly proportional to the electro-motive force, and inversely proportional to the resistance of the circuit.

Primary Facts and Conceptions of Electricity.—The ampere, volt, ohm and watt are the measurements. The phase is the fractional part of a period which has elapsed since a vibrating body last passed through the extreme point of its path in the positive direction. The direct current is constant. Alternating currents flow alternately in opposite directions. They are currents whose directions are periodically reversed. By the multiple circuit is understood a circuit in which a number of separate sources or separate devices or both have all their positive poles connected to a single positive lead or conductor and all their negative poles connected to a single negative lead or conductor.

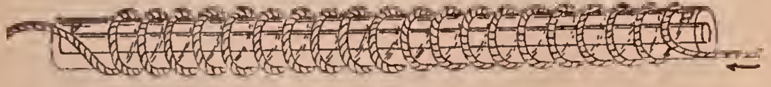
A series circuit is one in which the separate sources or separate electro-receptive devices, or both, is so placed that the circuit produced in it, or passed through it, passes successively through the entire circuit from the first to the last.

Instruments.—Galvanometers are used to detect currents and show their direction, and consist essentially of a rectangular coil of fine wire suspended on strained torsional wires in a strong magnetic field. The Wheatstone bridge measures resistances. The resistance of a conductor is directly proportional to its length, and inversely proportional to its sectional area.

Measurements.—Electrical measurements are made in a commercial way by means of various instruments, among which are the expansion voltmeter, the ammeter, which indicates the strength of current when its coil is included in the electrical current, and the recording voltmeter, which determines the element of time and others.

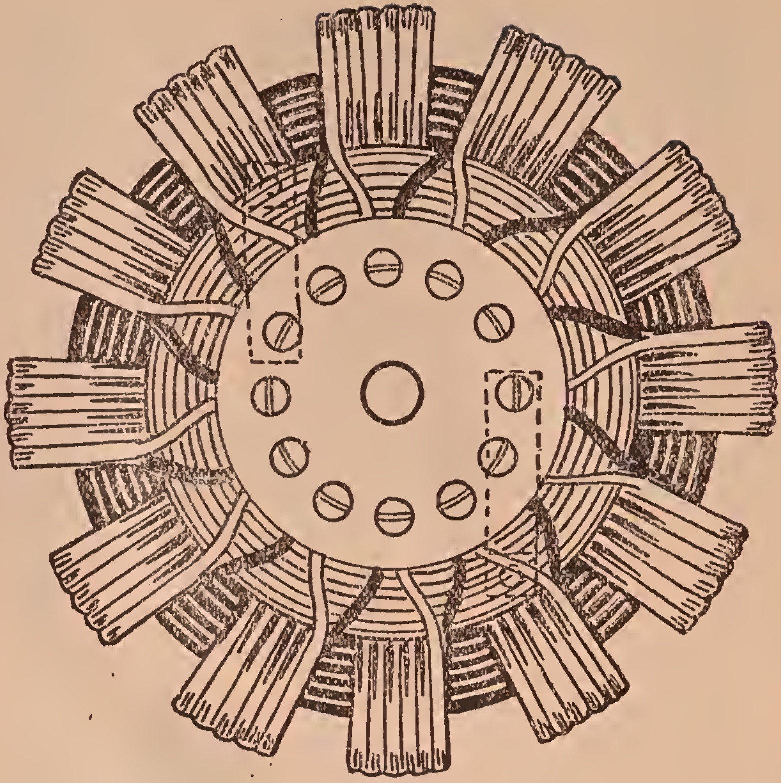
The Electro-Magnet.—An electro-magnet is a body of iron with an insulated conductor wrapped one or more times around it, and it depends on the form, size and quality of the iron core, number of turns the conductor makes around the coil, and upon the current passing through the conductor. The number of amperes flowing through the wire of a magnet, multiplied by the number of turns the wire makes around the coil of the magnet, gives the number of ampere turns.

When an electric current passes through a wire which is wound spirally around a piece of soft iron, as shown below, the iron then becomes a magnet, exhibiting polarity and attraction like a natural magnet.

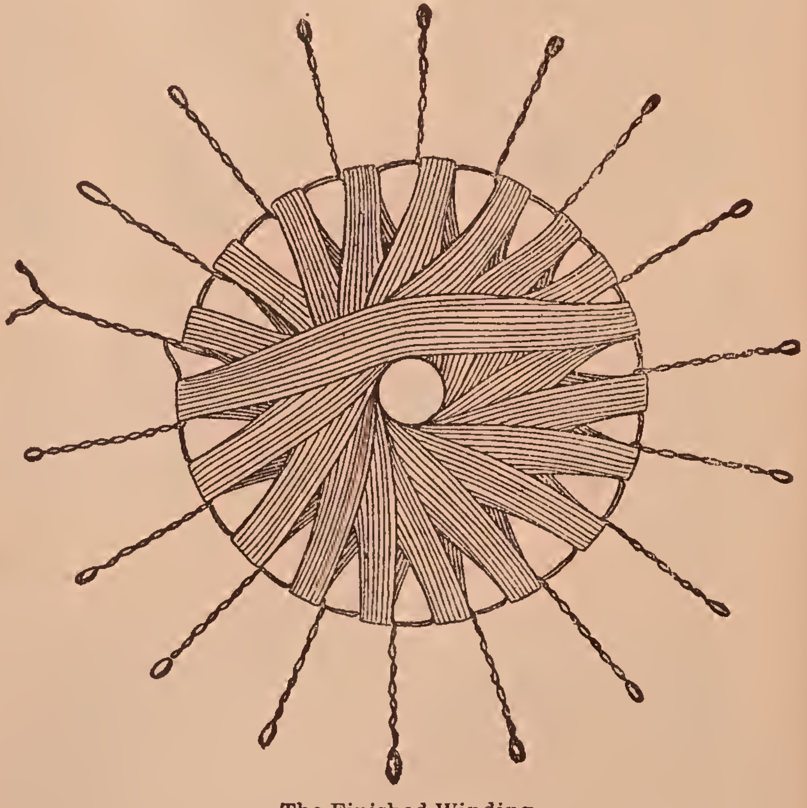


A Simple Magnet.—A bar of hardened steel surrounded by a coil of wire, traversed by an electric current, becomes permanently magnetic. All positive electrical impulses are generated on one side of the pole of the fixed magnet, and all the negative impulses are generated on the other.

Induction.—The process of induction carried on in the armature of a dynamo is well understood, the simplest form being the Gramme ring armature. The principal inductive effect is produced by the passing of a conductor through the magnetic field of the inducing magnet. In the Siemens, Edison, Weston and many other dynamos the drum armature is used.

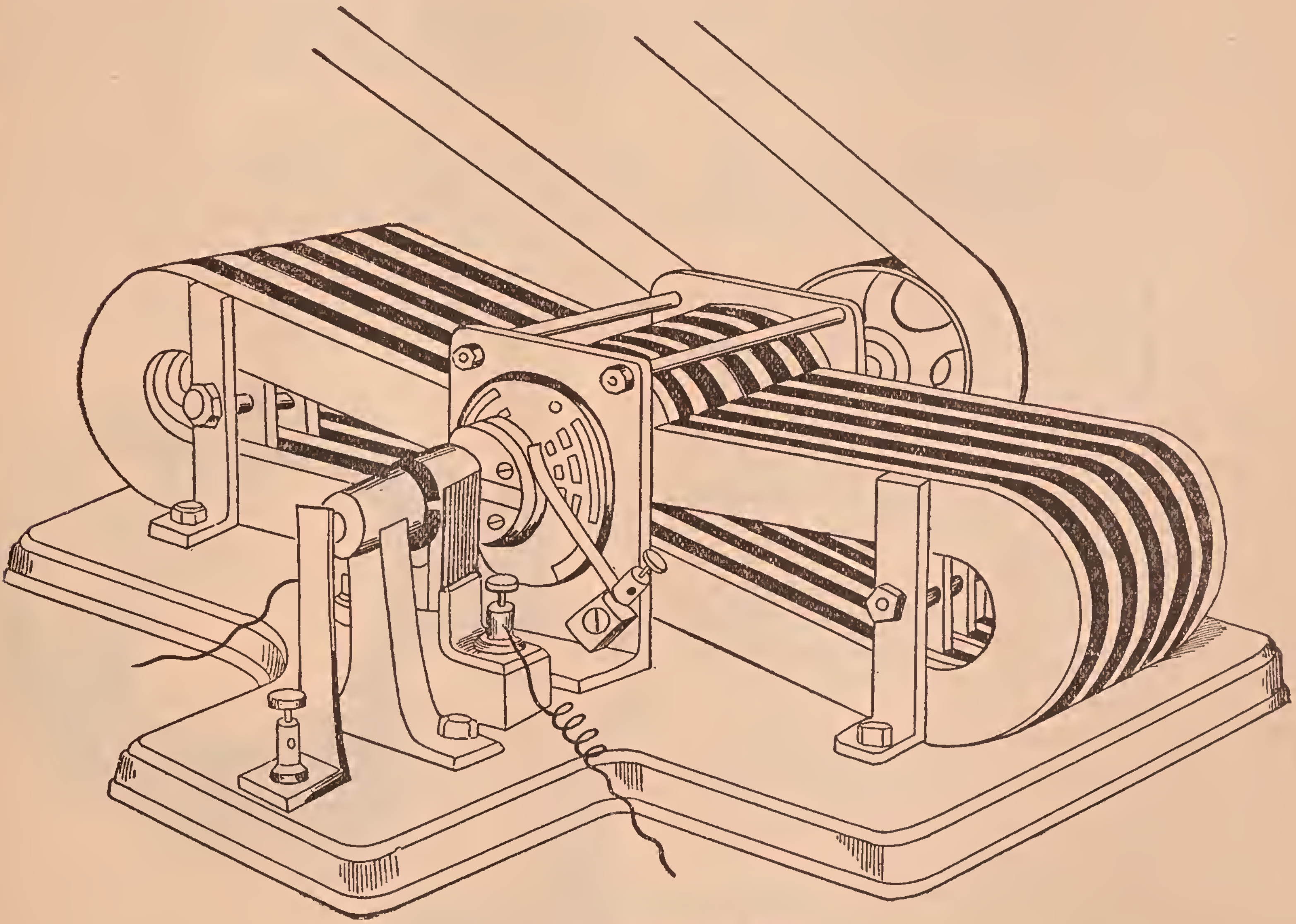


Armature Core Commutator.



The Finished Winding.

There are several causes which tend to prevent the increase of electro-motive force which is developed by the augmentation of speed attaining its theoretical proportion. The chief causes are the eddy currents produced in the core, the electromagnetic reaction of the current in the armature upon the field produced by the field magnets, and the self-induction of the armature. When a current is flowing round the armature coil, the whole armature is in reality an electro magnet, and it acts as such upon the poles of the permanent horseshoe magnet which supplies the field. This reaction tends to stop the motion of the armature.



Small Sized Magneto-Electro Machine.

Were it not for this reaction, it would cost no more to drive a machine when developing a strong current than when developing a small one. The work done in driving the armature consists chiefly in overcoming the mutual attraction between the armature and the field magnets.

Besides the waste due to eddy currents, which increases very rapidly with the speed, the effect of the self-induction of the armature becomes more strongly marked as it retards the rise and fall of the current.

If we wish to obtain in any given case an increase in the value of the electro-motive force obtained, it can be done in these ways: First, by increasing the speed of rotation, next by increasing the number of turns of wire in the armature, thus increasing the number of active limbs joined in series which cut out the lines of force. This method adds not only to the resistance, but also to the self-induction of the armature. Another method of obtaining an increase in the value of the electro-motive force is by increasing the area of the armature coils or by making the core more massive, as in either case the number of lines of force cut by the coil is, within certain limits, increased. Lastly, this result can be obtained by increasing the strength of the field, which is the freest from objections and has the all-important advantage that the stronger the fixed field, as compared with that developed by the armature, the less is the reaction and consequent distortion of the field.

The simplest way of maintaining automatically a constant potential is to consider the machine as a shunt-wound one; when the external resistance is made very low and the conditions are set up for the current in the shunt coils to be reduced to almost nothing, the magnetic effect of the series coils becomes a maximum. The success attending this method will depend largely upon the proper proportions given to the shunt and series coils. The combination shunt and series coils for the field magnet is the method commonly adapted to obtain a constant external potential, notwithstanding variations in the external circuit.

Magneto-Electric Machines. — A magnetized steel bar introduced into the coil acts the same as when the coil is provided with a soft iron coil, capable of being magnetized by induction, by contact or proximity to a permanent magnet. The Bell telephone is a familiar example of this species of generator-induced currents.

Dynamos.—Dynamos are of two kinds—those producing alternating and those producing continuous currents. The first current is composed of an infinite number of impulses of opposite polarity, one polarity being where a section of the armature coil is approaching the north field magnet pole or receding from the south pole, the other polarity when receding from a north field magnet pole and approaching a south pole.

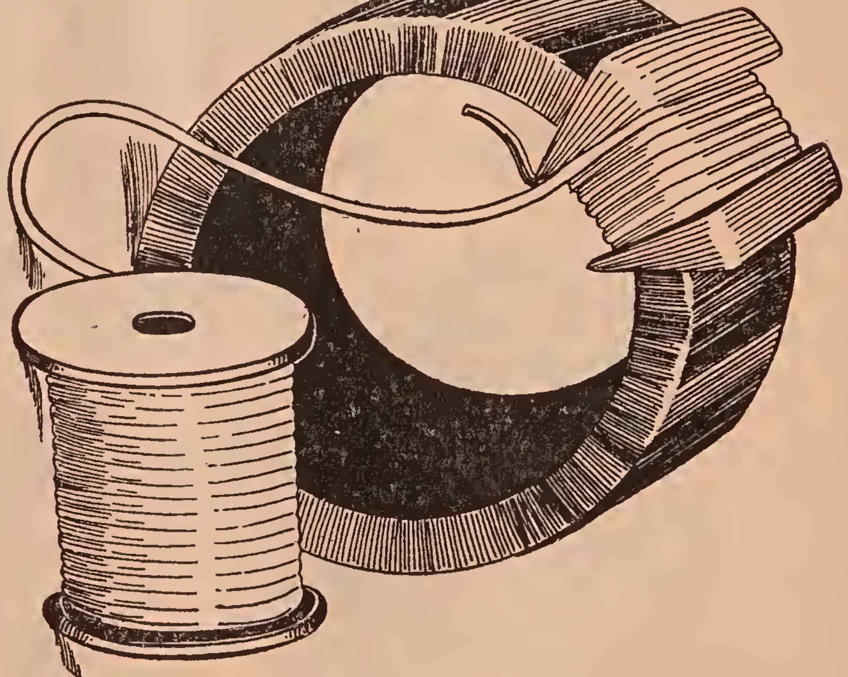
Management of Currents.—In the continuous current the commutator and brushes are so arranged as to take up all the impulses of the same polarity and conduct them away from one brush, gathering all the impulses of the opposite polarity and conducting them away by another brush.

Electrical Generation.—Electrical generation is developed into polyphase and multiphase or rotating currents. The revolving coils of the dynamo are known as the armature, and the fixed electro-magnets as the field magnets.

Achievements of the Dynamo.—The great advance of the dynamo is due to the greater flexibility and availability given by the alternating current to central station work. The size of the direct-current dynamo has apparently touched the upper limit, but the alternating dynamo exhibits a tendency to grow. The success of the long-distance transmission lines in California is only indicative of still greater achievements in the harnessing of the energies in absolute space for the use of man.

Machines in which steel magnets are employed for producing the field are also known as magneto-electric machines. They are sometimes regarded as a class altogether distinct from machines in which the field is developed by one or more electro magnets, but this distinction is not a necessary one. The best means available for increasing the electro-motive force and the strength of the current yielded by a machine is, as is well known, to increase the strength of the field; but there is a limit, which is soon reached, to the field attainable with permanent steel magnets, even if built up of thin sections, because the greatest number of lines of force which can be urged through steel is comparatively low. Primary batteries were at one time used to furnish the current to excite the field magnets. This current is now obtained by means of a small dynamo.

There is a class of machines in which both the armature coils and the field magnet coils are stationary, the cutting of the armature conductor by the lines of force set up by the field magnet being effected by moving masses of iron in such a manner that first a very good and then a very bad magnetic circuit are alternatively set up through the field magnet and the armature coils.



Winding the Armature.

In a complete armature of the modern type the core consists of a number of flat rings of well-annealed charcoal iron; sheets of thin paper insulate each disk to prevent flow of eddy current. The armature conductor consists of cotton-covered copper wire lying round the core and offering a resistance from brush to brush. The brushes are so placed that every division between the segments of the commutator passes under a brush just at the moment when the coil is idle.

Our Mechanical Workers and Applied Mechanism

Trade Secrets and Art of Handicraft

By J. M. DAVIS, Ph. D., LL.B.
Editor and Publisher of ENGINEERING-MECHANICS.

A COMPLETE HANDBOOK OF HELPFUL INFORMATION FOR EVERY MECHANIC AND ARTISAN.

Handiwork of American Mechanics

A VOLUME OF SPECIALLY WRITTEN ARTICLES TELLING THE BRILLIANT STORY OF OUR APPLIED MECHANICS IN EVERY BRANCH OF MANUFACTURE.

Agricultural Implements and Makers
Aluminum, the Making of
Artesian Wells, Boring of
Artificial Limbs, Making of
Automobiles and Bicycles
Babbitt Metal and Solder
Baking Industry
Ball-Bearing Utilities
Bells, the Making of
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Blacking, Manufacture of
Blacksmithing and Wheelwrighting
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Carpet Makers and Making
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Clothing Manufactures
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Dentistry, Mechanical
Electrical Apparatus
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Engraver's Art
Explosives, Manufacture of
Fertilizers, Making of
Fire Engines, Making of
Flour Making, Art of
Foundries and Foundrymen
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Gas Engines and Illuminants
Gas Stoves and Lamps
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Gloves and Glove Making
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Harness and Harness Makers
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Linens, the Making of
Liquor and Wine Making
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Paper Makers and Making
Paving Industry
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Photography
Plasterers and Plastering
Plumbers and Plumbing
Printers and Printing
Pumps and Pumping
Railroads and Railroaders
Ribbon Making Industry
Roofers and Roofing
Saw Making Industry
Scale and Balance Making
Sewing Machines and Makers
Ship Builders and Building
Shirt Making Industry
Silk Goods Making
Silversmithing and Silverware
Slaughtering and Packing
Smelting and Refining
Spring-Making Industry
Stationery Making
Steam Engine, Evolution of
Street Car System
Sugar Making
Tanners and Tanning
Telephone Mechanism
Tin Plate Making
Tobacco Manufacturing
Tool Makers and Tools
Type Foundry and Electrotyping
Watches and Watch Making
Wire and Wire Workers
Wooden and Stamped Wares
Woolens and Wool Workers
Worsteds, making of

SECRETS AND MYSTERIES OF THE MECHANICAL AND TRADE WORLD

A Unique and Wonderful Story never before told, and most Inspiring to the Genius and Pride of the Artisans, who have given their country a first place in Handicraft.

Our Mechanical Workers and Applied Mechanism.

Agricultural Implements and Makers.

Three Great Factors.—The three revolutionary agencies in the cultivation of the soil in the United States are seed drills and broadcast seeders, riding plows and cultivators and harvesters. Accompanying these great agencies, the systematic use of potash, phosphates and nitrogenous products as fertilizers, has done more even than mechanical improvements themselves to make the implement industry what it is.

Basic Factors of the Industry.—The twentyfold increase of cereals in thirty years is due to a number of causes, as follows: The influx of foreign population, the increasing purchasing ability of the masses of the people, the expansion of the railway system, which permitted the rapid and economic distribution of farm products; the production of implements at relatively small cost, which admitted of the cultivation of a much greater area; the cheapening of iron and steel, to say nothing of the improvement in the wearing qualities of the same, and finally the creation of an enormous and constant demand for cereal products in home and foreign countries.

Adaptation of Implements.—The agricultural implement industry itself is to be credited with much of the prosperity of American agriculture. Implements made cultivation of the soil possible where before it was not. For instance, in the matter of plows, there are over a hundred styles and makes of plows, each designed for special, or it might be said peculiar requirements, such as hillside cultivation, lowlands, swamp land, virgin land, and so on. The requirements of the soil have been accurately and scientifically studied by the implement makers, with a view of securing the largest as well as the most economic results in crops.

The Harvester and Its Significance.—The harvester proved to be the grand turning point in the implement industry. This machine in its primitive condition was a scythe in a man's hand. Its gradual evolution during the past sixty years is typical of the progress of man in the United States. The early harvesting devices to which a horse was attached, consisted practically of a long knife, so attached to a crude vehicle as to be actuated by horse motion against standing grain. The first harvester was a revelation as to agricultural possibilities. The horse from that moment became a greater factor. The farmer saw vast possibilities. The prairies were instantly enslaved to man. The railroads saw in the harvester a giant freight producer. The mechanic, with prophetic insight, saw in it the basis of a new industry wherein his latent skill would find employment. The merchant saw in it the basis of trade that would fill his store with goods. The people, if they could have foreseen the future of the invention, would have seen cheap and abundant bread.

Influence of the Industry.—The roots and branches of the agricultural implement industry extend deep and far. This industry penetrates a hundred other industries, furnishes traffic for 50,000 miles of railroad, furnishes employment for fleets of lake and ocean ships, affords activities for hundreds of cities and towns, and stimulates industry in almost every country on the globe. The expansion of agriculture reacted upon inventive talent and stimulated improvement, until the complex and intricate, yet simple machinery, as embodied in the harvester of to-day, was evolved.

Plows.—Among the plows now manufactured are the one, two, and three-horse plows, walking or riding plows, plows with steel beams and wearing parts, or wood beams and steel wearing parts; right or left-hand plows, two or three-furrow gang plows, timber-land, vineyard or orchard, prairie, unbroken land plows, and plows particularly adapted to different qualities of soil and inclination of land. The modern plow is manufactured in interchangeable parts, so that the moldboard, share, landside, standard, coulters, clevis, and the different bolts, braces, staples, washers, etc., may be readily renewed when necessary. Upward of 250 patents have been issued for steam plows, and upward of 15 patents for electric plows.

Harrows.—Improvements in harrows have been shown in the extension of the disk and spring-tooth principles. The three general classes of harrows are the spike-tooth, disk and spring-tooth harrows. Steel-lever sectional harrows with spike teeth are made in one, two, three or four sections, with adjustable teeth, which, by means of a lever, can be set at any angle required.

Spring-Tooth Harrow.—The spring-tooth harrow has been greatly improved, and among the improvements may be mentioned the adjustability of the teeth to any depth or angle required, the construction of the frame of iron or steel, the application of wheels or runners which lessen the draft, and a seat for the operator. The steel teeth number from ten to thirty-five, and in some cases are self-sharpening.

Disk Harrows.—In the disk harrow, used from earliest times, the disks are made either concave, convex or straight, of varying diameters, and are made in one gang or more, each controlled by an independent lever. They have automatic scrapers, anti-friction bearings, solid or cut-away disks, one, two, three or four-horse hitches, and the seeder attachment, and also sometimes a hoe attachment to level the intervening furrow.

Cultivators.—Riding and walking cultivators are made with and without wheels, to which have been adapted the disk and spring-tooth. There are improvements in couplings and springs and in hammock riding attachments. Wearing and bearing parts and frame are mostly of steel, beams and handles of wood. The gangs of shovels are regulated at will, and the implement is adaptable to the varying widths of the row.

Seeders and Planters.—Crude seeders and planters were used seven centuries before the Christian era. In 1731 Jethro Tull, of England, the originator of horse-shoeing, introduced horse-power in seeding and planting. The disk feature is one of the more recent improvements in the drill and the broadcast seeder attachment to the disk harrow.

The drill seeder is used for sowing wheat, rye, oats and barley in equidistant rows; but by shutting off or removing some of the hoes or drills, this implement may be used for other crops, such as beans, peas, turnips, sugar beets, corn, grass seed, etc., and for fertilizer. Some are made to seed seventeen rows, and are provided with a force feed to gauge the amount of seed dropped, and which have a lever for forcing the hoes into the soil and changing their angle of inclination. Some disk drills have scrapers or cleaners, and some drill seeders are convertible into broadcast sowers by attaching scatterers to the feed seeder in place of the grain tubes.

Corn Planters.—The later corn planters are a two-horse machine, of steel, with two seed-boxes and check-runner, drill and force-drop attachments, secured by a lever which forces the runners to work at equal depth under different conditions.

Harvesting Implements.—The scythe in early ages took the place of the primitive bronze reaping hook. Next came the grain cradle. A machine for mowing by horse-power was patented in 1812. Numerous inventions followed until 1833, when Obed Hussey introduced an improved mower and cutting apparatus which was the basis of most succeeding inventions. The end of all inventive effort has been to combine in one machine all the operations necessary in the field, which are, to cut the hay or grain, to rake, bind, cut and thrash.

Other Farm Implements. — Among the various machines invented and used are reapers, harvester binders, bean and clover harvesters, corn harvesters, cotton harvesters, hemp and flax harvesters, combined reapers and thrashers, horse rakes, hay forks, hay loaders and hay tedders.

The Grain Harvester.—The latest grain harvester is constructed in nearly all parts of iron and steel and of utmost safe lightness; it has wide wheels, improved axle bearings, adjustable cutting apparatus and grain wheel and divider to separate standing from cut grain, a reel to deposit the grain on the platform, and an elevator to carry the grain from the platform to the automatic twine binder. This automatic self-binder was the culminating improvement in grain-harvesting machines. The combined reaper and thrasher, on account of climatic conditions, can be used only west of the Rocky Mountains.

The Corn Harvester.—By the use of the corn harvester the corn is cut, formed into bundles, and bound and deposited on the ground.

Haying Tools.—The old wheeled hand-rake was followed by the spring-tooth hay rake, the dumping sulky, the draft-dumping, the self-dumping and the spring-tooth dumping, all of which are constructed almost entirely of steel. The side-delivery rake, used in connection with a hay loader, is a recent improvement. The hay tedder is used to turn hay for the purpose of curing. Other minor improved devices are the spiral horse fork, the single or double harpoon fork, the tilting horse fork and the grapple horse fork.

Hay and Straw Baling Presses.—The mounted hay-baling machine gave increased importance to the cultivation of hay. The baling press, traveling from farm to farm, has virtually created a new industry. A continuous press, invented in 1872, is now in quite general use.

Thrashers and Separators.—The modern steam-power thrasher and separator is used for separating small grains; its motive power is a traction or portable engine, from 6 to 25 horse-power. The bundles are fed to the machine, which cuts the bands, thrashes, winnows, sieves the grain, and stacks the straw. The fire-box has been adapted to the use of straw as fuel.

Hand and Power Corn Shellers.—If the corn crop of the United States were shelled by hand, it would take the entire population of the United States 100 days each year to do the work. Certain types of corn shellers are made to be operated by steam-power or hand, and 700 bushels per hour is the capacity of some shellers.

The Implement Manufacturer.—To the implement manufacturer belongs the credit and the distinction of making such results possible. This industry has developed a special type of inventive ability. The aim and purpose of the implement inventor has been to liberate man from drudgery and enable him to apply his intelligence, skill, knowledge and observation to the securing of the greatest results from the land. The implement manufacturing industry has become one of the greatest industries in the United States.

One Reason of Rapid Progress.—The perfection of implements, and their comparative cheapness when measured by results, was largely due to the adoption of standard sizes, gauges and parts, an American inception which has practically revolutionized the theory and practice of mechanical arts. A diversification of manufacturing set in in the infancy of the industry, under which the work of producing each or some of the individual parts was divided up, each branch of industry producing its own specialty.

Divisibility of Parts.—Herein is to be found the secret and strength of the implement industry. The cost of each part was thereby reduced to a minimum. The task of associating the various parts of iron and woodwork devolved upon another branch of workers, who developed, through practice, a degree of skill and aptitude the equal of which it would be difficult to find in any other industry.

Adaptability of Implements to All Conditions.—In the implement industry, recognition is taken of all the varying requirements, difficulties, obstacles and emergencies which the implement being produced may encounter. The quality of the steel, malleable, forged or open-hearth, its elastic requirements, its wearing endurance, the seasoning of the properly selected woods and their proper manipulation in the wood-working departments, and finally the harmonious association, as a united and orderly whole, into an implement to be used by manual or animal labor or to be operated by the agency of steam, are all the subject of skill and careful manipulation in their manufacture.

Influence of the Implement Industry.—The implement industry as it stands to-day in its economic relation to the production of cereals and other products for sustenance, presents many inviting and instructive aspects apart from mere utilitarian applications. It has made possible conditions of society and developments of capacities in the individual and in society that otherwise, it is easy to conceive, might have remained more or less dormant. The agricultural implement is an instrument of civilization which has no counterpart. It made possible and necessary the construction of the transcontinental railway system of the United States, made also possible the development of the vast mineral wealth, and has brought us up to the problem of the recovery of upward of 600,000,000 acres of arid lands for the future benefit of man. It has increased the use of wheat in foreign lands in preference to cruder foods, has created a vast inland and ocean traffic, and has laid the broad and enduring foundation for an ever-expanding market for the manufactured products throughout the United Sates. It has created the conditions for a political, commercial and social unity among the people which no other industry can approach in importance. It has made it possible for the masses to possess themselves of the means of subsistence at a cost far below that which would have been possible had it not been for the introduction of mechanical appliances for the cultivation of the soil.

A Comparative View of the Agricultural Implement-making Industry in the United States is as follows.

	1880	1890	1900
Number of establishments	1,943	910	715
Capital invested	$62,109,660	$145,313,977	$157, 07,951
Wage-earners	39,580	38,827	46,582
Wages paid	$15,359,610	$18,107,094	$22,450,880
Value of products	$68,640,486	$81,271,651	$101,207,428

The above table is interesting as showing the tendency among the larger industries in the United States to concentrate effort. Thus, in 1880 there were more than twice as many manufacturing establishments of agricultural implements as in 1900, yet the value of products was but little over one-half.

Aluminum, Making of.

Its Chemistry.—Aluminum is one of the most widely distributed metallic elements. In one method of its getting or manufacture, aluminum is held in solution by a molten fluoride bath. An electric current is conveyed to the melted solution by means of carbon cylinders placed in the bath for positive electrodes, a carbon-lined pot forming the negative electrode. The oxygen of the aluminum gives off a carbon dioxide, wearing away the carbon equally with the aluminum. The reduced metal settles at the bottom of the pot, and is tapped off, yielding 99 per cent. purity.

Production.—The total production in the world in 1899 was 12,254,838 pounds, of which about one-half was produced at Niagara Falls. In 1855 the price was $90 per pound. Its present price is under 30 cents per pound in rods and bars for electrical conduction.

Properties.—Like gold and silver, aluminum hardens in working, and rods and wire vary in strength. It is manufactured by bringing together on a large scale 10 parts of the double chloride, 5 of cryolite and 2 of sodium in a reverberating furnace. The tensile strength of aluminum is found to be 26,880 pounds per square inch as compared to 16,500 pounds for cast iron, 50,000 pounds for wrought iron, and 78,000 pounds steel. Its mechanical properties show it is suitable where strength combined with lightness is required and a great range of elastic action is needed. Its elastic range is three times that of steel and five times that of wrought iron. It makes good beams for balances.

The electrical conductivity of silver is 100, copper 90, aluminum 50, and its thermal conductivity 38, as against 73.6 for copper and 100 for silver.

Alloys.—Alloyed with copper it is known as aluminum bronze, with silver as tiers argent. It is slowly increasing in use for domestic purposes and in optical instruments, as well as in military accoutrements and for electrical conductors.

Tenacity. — Aluminum ranks second only to steel in tenacity; is one-fourth as heavy as silver; non-volatile at very high temperatures, conducts heat and electricity as well as silver; does not oxidize even at red heat, and resists the action of water, sulphuretted hydrogen, concentrated nitric acid and dilute sulphuric acid.

The Cowles Process.—Aluminum was first separated in 1828 by decomposing the chloride by means of potassium. The present condition of the aluminum industry is due to the Cowles process, which heats to incandescence by the electric current a mixture of alumina, carbon and copper, the reduced aluminum alloying with the copper.

An enormous industry has been built up at Niagara Falls. Aluminum, by reason of its cheapness, has become a very important material for a rapidly increasing number of practical uses in the arts and industries.

Use as a Sharpener.—A German experimenter, Herr Bernhard, noting the structure of aluminum, decided to try it for putting an edge on fine cutting instruments, such as surgical knives, razors, etc. He found that it acted exactly like a razor hone of the finest quality. Further investigation showed that, when steel is rubbed on it, the aluminum disintegrates, forming a minute powder of a greasy, unctuous nature that clings to steel with great tenacity, and thus assists in cutting away the surface of the harder metal. So fine is the edge produced that it cannot be made finer by the strop, which, used in the ordinary way, merely tends to round the edge.

Production. — The production of aluminum in the United States during 1902 was approximately 7,300,000 pounds, as compared with 7,150,000 pounds in 1901, an increase of 150,000 pounds, according to a report on the production of that metal by the United States Geological Survey. One company has in operation 11,000 horse-power at Niagara Falls, N. Y., and 5,000 horse-power at Shawinigan Falls, Quebec, a total of 16,000 horse-power, which is equivalent to a capacity of 4,500 tons of metal yearly.

Artesian Wells.

Derivation of Name.—The artesian well derived its name from the province in France named Artois. It is probable, however, that wells to secure supplies of water were bored ages ago in Egypt and China. Artesian wells are made by boring the earth in such localities where from internal pressure water flows spontaneously like a fountain. They are usually of small diameter and of great depth. The geological conditions must be of such character as to permit of a pressure of water through an orifice.

Where Found.—Artesian wells are very common in many sections of the West, where they are bored at relatively small cost and afford an abundant supply of water. Occasionally artesian wells are bored in other sections of the country, and which supply abundant volumes of water, mostly for manufacturing requirements.

Improved Methods.—Great improvements have been made in well-drilling plants, one of the latest inventions being the adaptation of an electric motor to deep-well boring. The drill is inclosed in a water-tight casing suspended from a derrick by a cable with necessary conductors attached for reaching the desired depth. It is provided with signaling devices whereby the operator can tell by the sound whether the work is proceeding in a satisfactory manner.

Cutting Device.—The object of another device is to enlarge the hole in the rock below the casing so that it may be sunk to a lower depth when, for any reason, this becomes necessary. It consists of an expansible cutting device which can be passed through the casing by suitable manipulation.

Artificial Limbs.

Sources of Accidents.—The necessity for artificial limbs is largely due to accidents received in workshops and on trolley and steam railroads. When it is remembered that accidents on railroads in the United States average 1,000 per week, and that probably as many or possibly more unreported accidents occur in the workshops of the country, it is not difficult to recognize why and how the industry of manufacturing artificial limbs exists. The percentage of accidents which results in loss of limbs is increasing decade by decade, as well as per head of population.

Statistics.—The number of manufacturing establishments engaged increased from 33 in 1880 to 59 in 1890 and 87 in 1900; wage workers increased in those years respectively from 72 to 162 to 249, and the value of work done from $137,024 to $475,977 and $749,854 respectively, an increase of over fivefold in twenty years.

Progress in Manufacture.—Remarkable progress has been made in the manufacture of limbs, and especially as to the ease with which they can be worn. They are so adapted to the body that their use is liable to slip the observation of the casual observer.

First Patent.—Until about the middle of the nineteenth century the survivor of a surgical operation in which a limb was involved was a pitiful object. The first patent for an artificial leg was granted in 1846. Marked improvements were made between 1853-1863 by inventors, who, in the latter year, used sponge rubber for the construction of artificial feet and hands, which dispensed with articulated joints. About 1887 an inventor introduced a foot and leg portion of a wooden leg made from wood which grows with a crook, as at the root of a tree where the strength and lightness of a continual natural grain is obtained at the instep.

Modern Improvements.—Over 300 patents have been taken out for artificial legs and arms, and modern improvements extend to every detail of construction. In fact, it is difficult to recognize a wooden leg attached to the stump. Men ride horseback, use the bicycle, and occasionally are found to perform on the tight-rope, who wear artificial limbs.

The skill of artificial limb makers has gone beyond the prescribed limits of limb making, and produces among other aids artificial eyes, eardrums, audiphones, etc. The value of the products is now over one million dollars annually.

Comparative Summary of the Artificial Limb Industry.

	1880	1890	1900
Number of establishments	33	59	87
Capital invested	$82,600	$186,896	$290,104
Wage-earners	72	162	249
Wages paid	$13,833	$102,438	$146,620
Value of products	$137,024	$475,977	$749,854

Automobile and Bicycle, Mechanics of.

Early History.—The first automobile was made long before the first locomotive. It was foreshadowed away back in the thirteenth century, and was foretold in the fourteenth century by Roger Bacon. Cugnot, in France, in 1769, produced a steam automobile; in the year following an improvement on it appeared, which is still in existence. Richard Trevethick in 1802 built a steam road carriage, and in 1825 a successful one appeared. Hancock in 1839 brought out a number of steam vehicles, one of which was an omnibus, and which was operated between London and its suburbs. These were soon followed by others built by J. Scott Russell, which ran between London and Scotland, and attained a speed of twelve to fifteen miles an hour on good roads. They aroused popular tumult, and were discontinued.

Automobile Development. — The next era was the introduction of traction engines, which resulted in the building up of an important industry in England. This was followed by the modern automobile era. Various prizes were offered a few years ago for the production of an automobile, or horseless vehicle, as it was then termed, and inventive ability was stimulated. Contests were encouraged; there were frequent trials and tests of the new machines, and defects and requirements were studied.

The Gas Engine.—A great impulse was imparted to the automobile by the perfection of the gas engine, which had for a generation attracted the attention of mechanics, inventors and mechanical engineers. The practical perfection of the gas engine opened a clear road for the automobile. It was then but a question of mechanism and public acceptance.

The Combustion Motor.—For combustion motors, as well as for the generation of steam for engines, gasoline is now the standard and recognized fuel of common practice. The work that has been done on these motors is almost infinite in variety and extent. For automobile work the gases have been practically disregarded, on account of the space and weight required for storage, to which must be added the expense of compression. Experiments made with acetylene have not as yet proven satisfactory.

Mechanical Points of Construction.—The objective points in most automobile construction are lightness, strength, speed and capacity. The ideal motor is silent and free from vibration, which is realized in the electric motor, while in the gasoline or steam motor noise and vibration are difficult to overcome. Vibration is largely eliminated by the use of two cylinders whose cranks are set opposite each other. Since 1898 there has been a marked tendency to do away with the cooling of the cylinder by the circulation of water, and to replace it either by an energetic ventilation with a fan driven by the motor or by enlarging the radial surfaces.

In order to obtain the best efficiency of a gasoline motor the ratio of the speed of the vehicle to that of the motor should be changed without varying the latter, which should remain constant and retain its normal maximum value. This is an ideal that has not been attained in automobile carriages, but there are gradual approaches to this solution.

Compensating Gear.—When electric propulsion is used, with two motors driving the wheel at opposite ends of the axle, no compensation is needed, but for gasoline and steam motors delivering power direct to the axle, some form of compensating gear is used in order to enable the vehicle to move in a curved line without a bridling or slipping of the wheels. Elaborate tests show that decided advantages are gained by the use of pneumatic tires.

Steering Apparatus.—As to steering, French automobiles are usually operated with a hand-wheel and worm gear. American machines ordinarily have a lever for steering, which, while quiet in action, renders it necessary for the driver to have his hand upon it at all times. The fundamental idea of all steering gear is that when on a curve the central line of the axle of each wheel should radiate from a single point if side-slipping is to be avoided.

Growth of the Industry.—The growth of the industry has been so rapid, and the introduction of the automobile has been so successfully accomplished, that there is hardly a type of horse-drawn vehicle that has not its counterpart in one propelled by steam, gasoline or electricity.

The Automobile Field.—Any description of the various makes of American automobiles is manifestly beyond the scope of this review; while there is a broad field for the pleasure vehicle, there is a broader one for the automobile delivery wagon and truck, if certain defects well understood can be overcome.

The Automobile on the Farm.—A few automobiles have been successfully adapted to farm use, especially in the mowing machine, but the practical utility of automobilism for purely agricultural purposes is problematical.

The Improvements in Sight.—The automobile has not yet found its true base. Different classes of inventors are at work experimenting along parallel lines. One class is seeking to produce automobiles of from 500 to 800 pounds' weight, good for ordinary distances, that will retail at $300 to $500; another class is pushing forward in the direction of heavy trucks, and with gratifying prospects. Others are introducing improvements consisting in borrowing carriage features, as, for instance, tops for protection and other carriage devices. Still others are seeking to produce machines of enormous speed and endurance.

Automobile Statistics. — The latest enumerations show that there are 398 manufacturers of automobiles in the United States and 739 dealers. New York leads, with 83 recorded builders and 138 dealers; Massachusetts, 63 manufacturers and 58 dealers; Ohio, 51 manufacturers and 49 dealers; Pennsylvania, 32 manufacturers and 71 dealers; Illinois, 33 manufacturers and 37 dealers. In 1900 there were built 3,901 automobiles, of which 3,472 were for pleasure uses and 429 for delivery and transfer purposes.

Automobile Clubs.—Associations of manufacturers exist for the conservation of mutual interests, and automobile clubs are springing up, designed to promote good-fellowship and to combat unfavorable legislative supervision or control, as well as unfair municipal rules and regulations. It is estimated that there were over 40,000 automobiles in the United States in 1902, and the number was greatly increased for 1903. An estimate for the probable production for 1904 places the figures as high as 30,000.

As to the Bicycle.—In 1869 the entire bicycle was made of iron and steel; solid rubber tires and brakes followed. The pneumatic tire was the basis of the abounding popularity of the machine. It furnished not only an elastic bearing which cushions the jar, but also makes a broader tread that renders cycling on soft roads of the country more agreeable. The latest innovation was the chainless wheel, which connects the axle of the pedal-crank with the axle of the rear wheel by a shaft with beveled gears. All parts of the bicycle of to-day have come in for a share of attention at the hands of inventors, who have brought out a variety of differential speed-gears and brakes. Nearly 5,000 patents have been granted on bicycles and tricycles, but notwithstanding the great popularity for upward of a decade, this form of amusement is subsiding.

Comparative Summary of the Bicycle and Tricycle Industry.

	1890	1900
Number of establishments	27	312
Capital invested	$982,014	$8,189,817
Wage-earners	1,797	17,525
Wages paid	$982,014	$8,189,817
Value of products	$2,568,326	$31,915,908

The figures of the Government for 1890 were evidently gathered carelessly.

Awnings, Tents and Sails.

Utility.—Within twenty years the manufacture of awnings, tents and sails has increased sixfold, which fact is measurably explainable by the greatly increased use to which such products are put. The custom of many householders in providing window protection to direct sunlight has created a material demand. The use of tents for militia purposes and for summer outing has likewise considerably increased factory activity. The decline in sail tonnage has cut off some of the former profitable demand, but other sources of trade have more than compensated for this loss.

Statistics.—Domestic and office requirements of these products of canvas are growing with great rapidity. Twenty years ago the value of these products was less than $2,000,000. At present the average output is in excess of $12,000,000 annually, and the number of persons engaged increased during that period from 1,268 persons to 4,400, employed in 858 establishments, in 1900, as against 151 shops in 1880.

Babbitt Metal and Solder.

A Peculiar Industry.—The extraordinary value of Babbitt metal as a bearing to lessen friction and its numerous attendant evils, has, with the unprecedented expansion of machinery and mechanical appliances, created a department of industrial activity peculiar to itself. The fortunate discovery of this most valuable composition relieved the mechanical world of accumulating disadvantages, and made possible the construction and operation of machinery on a scale and with an economy otherwise practically impossible. It is the most valuable composition known for its purpose, and its object is to prevent, or rather minimize, friction of parts of machinery, particularly in journals where there is great pressure and speed.

Solder.—Solder, though not serving the same purpose, is usually produced in the same establishment and sold with it. It is used to cover or surround joints, to prevent the escape of fluids and gases through the minute crevices or interstices which exist in certain mechanical construction. It is the plumbers' vade mecum, and the inseparable companion of many mechanics where the nature of the work demands the closing of avenues of escape of contained liquids or gases.

Solder is an alloy, and is termed hard or soft, the hard fusing at red heat and the soft at comparatively low temperature. Solders are variously made. One is made of 2 parts bismuth, 1 tin, and 1 lead. Tin melts at 455 degrees Fahr., but the alloy melts at 200 degrees. Less bismuth increases the melting point. A solder can thus be made to fuse at any desired temperature between 212 and 329 degrees.

Babbitt and White Metal.—Babbitt metal and Carson's white brass are most valuable anti-friction alloys. The term "white metal" is applied to all alloys in which zinc, tin or lead is in sufficient proportion to impart a white color. Babbitt metal is made of various composition. Generally it may be described as a tin alloy, 10 parts tin with 1 part each of copper and antimony.

Variety of Compositions. — A solder for brass work is made of equal parts of copper and zinc, or, for fine work, 1 part silver, 8 parts copper and 8 zinc. Hard solder is made of 865 copper, 9.5 zinc and 4 tin. For copper, 3 parts copper, 1 zinc; or, 7 copper, 3 zinc, 2 tin. Hard spelter solder is made of 2 parts copper, 1 zinc, and is good for iron work. A middling hard solder is made of 4 parts scrap of metal to be soldered with 1 zinc. Hard silver solder is made of 4 parts silver, 1 copper, or 2 silver and 1 brass wire. For sealing canned goods, take 1¼ pounds lead, 2 pounds tin, 2 ounces bismuth; melt the lead first, then add tin, and last, bismuth stirred in well just before pouring. A soft solder for joining electrotype plates is made of 67 parts lead, 33 tin. For steel, 19 parts silver, 3 copper, 1 zinc. For tinned iron, 7 lead, 1 tin.

Alloys for Bearings.—In connection with Babbitt metal, phosphor bronze and manganese bronze for bearings, cadmium is also used. Railroad engineers have tried almost everything to get the best anti-friction alloy. Tin and copper are too hard. White-metal bearings, with copper and antimony predominating, is too brittle and breaks under heavy loads.

Bismuth Bronze.—This is a very good alloy for telegraph and music wire and for domestic articles, and is made with 69 parts copper, 21 spelter, 9 nickel and 1 bismuth. It is hard and tough.

Comparative Summary of the Babbitt Metal and Solder Industry.

	1880	1890	1900
Number of establishments...	9	36	51
Capital invested............	$73,100	$954,654	$3,115,568
Wage earners...............	44	173	535
Wages paid..................	$18,745	$84,283	$294.584
Value of products...........	$262,950	$2,905,102	$9,191,409

The value of these products has increased approximately thirtyfold within twenty years, an expansion greater than is shown in any other industry. It is explained by the enormous expansion of mechanism, and is a fair measure of mechanical progress. Notwithstanding the great increase in output of copper, lead, zinc and silver the market prices of Babbitt metal and solder vary only within fractional limits, because of the remarkable expansion in demand.

Bag Making.

Growth of the Industry.—The necessity for receptacles to hold a great variety of commercial products in their natural state, or milled or more or less pulverized forms, has built up an industry the annual value of the products of which are in excess of $20,000,000. The economy of bags for filling, handling, shipping and for easy and quick distribution purposes has led to their adoption in all commercial and manufacturing avenues where convenience can be subserved. No other substitute has been found. The use of lumber as material for packages is impracticable. Bags, on the other hand, are more easily and readily made, there being an abundance of material always available and an abundance of factory equipment for their manufacture. They carry more merchandise for the space occupied, can be reshipped at small expense, are more durable than packages of other material and permit of some degree of evaporation and circulation of air which is sometimes desirable. They are convenient for ocean and railroad traffic and for handling through retail channels of distribution, and enable merchants to regulate quantities to meet the requirements of their business.

The accompanying figures exhibit the extent and growth of the industry:

Comparative Summary of the Bag (other than Paper) Industry.

	1880	1890	1900
Number of establishments...	64	80	73
Capital invested............	$4,917,000	$9,347,787	$7,696,732
Wage-earners...............	5,451	6,633	4,039
Wages paid..................	$1.603,785	$2,049,832	$1,133,128
Value of products...........	$13,238.253	$20,207,805	$20,123,486

Decrease of the Industry.—There is a tendency, however, at work to relatively reduce the quantity of merchandise shipped and handled in bags by reason of the large shipment of many commodities in bulk and their preparation for final distribution to consumers in different forms than bags. This tendency is shown in a slight decline during the past decade in the capital invested in the industry and a fractional decline in the value of products as well as in a reduction of almost one-third in the number of wage workers engaged. Another cause for the decline in the fibre bag industry is the remarkable expansion of the paper bag industry, which has within a few years been developed to a high state of practical efficiency. Paper bags are cheaper and more safely carry a large number of products, especially for household and personal requirements.

The Baking Industry.

Baking Long Ago.—Baking was known in earliest times. In Numbers we are told that the people went about and gathered manna and ground it in mills or beat it in a mortar, and baked it in pans. Isaiah says, "Yea, ye kindleth it and baketh bread."

Nutrient Values.—The nutritious qualities of wheat vary greatly. While the baker may give a certain weight of loaf, he by no means assures the buyer a given amount of nutrition from its use. Spring wheat, for instance, grown in the Red River Valley of the North, Minnesota, North and South Dakota, is said to contain a larger percentage of gluten, more phosphate, more health-giving and health-sustaining qualities than much wheat grown elsewhere. Most wheat used for flour is winter wheat, and is usually soft and contains a smaller percentage of gluten and phosphates and is a cheaper and inferior material for bread, cake and pastry. To most housekeepers flour is flour, because different flours do not indicate the various quantities of nutrition contained.

The Gradual Reduction Method.—The present method of grinding wheat is known as the "gradual reduction" method. The wheat is granulated instead of pulverized, and slightly crushed, after which the middlings or grits are separated. The wheat goes through, in many mills, six sets of breakers, the rolls in each successive breaker being closer together. Hence there are six different grades in size and quality.

Baking Powders.—Cake-baking methods are greatly facilitated, as well as simplified, by the use of baking powders, the manufacture of which has reached immense proportions. By means of these powders more uniform results in cake baking are secured than where each baker or housewife is restricted to using baking soda, the old-time method. The baking and baking-powder industry has doubled during the last decade, and has increased three and one-half times in twenty years. The ease with which biscuit baking is done by the use of various yeasts, the ease with which small purchases of flour can be made, the wonderful adaptation of culinary apparatus for quick baking, and the growing preference—but not always hygienic preference—for hot bread in different forms, have united to create and sustain a demand for baked products of wheat and for powders for facilitating baking processes which have built up an industry of enormous proportions, as the appended interesting statistics show.

Proportions of the Industry.—The industry of baking has latterly assumed vast proportions, and old-time household baking, with all its mistakes and shortcomings, is disappearing. Home-baking requires considerable skill, which is not universal. Then, the changing conditions of society, the absence of suitable ovens and the lack of time to devote to baking, all unite to make the baker a more important factor in modern society.

Science of Baking.—Besides this, the science of baking, both from its mechanical and chemical standpoints, has been greatly improved and more thoroughly understood. The facility with which fresh bread can be made and offered for sale, makes its preparation in the homes almost unnecessary. The old-time oven, which was heated with wood, is no longer a possibility in urban surroundings, and even in rural sections it is being neglected and hot bread in various forms substituted, even though there are hygienic reasons against its too constant and too liberal use. The baker has become a necessity of the age, and the success with which he does his work is making him a still more valued member of the great family of industries.

Comparative Statement of the Baking and Yeast Powder Industry.

	1880	1890	1900
Number of establishments..	110	150	191
Capital invested............	$1,350,600	$3,587,919	$8,337,723
Wage-earners...............	1,042	1,441	1,938
Wages paid................	$466,252	$574,241	$717,000
Value of products..........	$4,760,508	$7,406,806	$14,568,380

Comparative View of Bread and Other Bakery Products.

	1880	1890	1900
Number of establishments..	6,396	10,484	14,917
Capital invested............	$19,155,286	$45,758,489	$81,049,553
Wage-earners...............	22,488	38,841	60,271
Wages paid................	$9,411,328	$19,120,259	$27,893,170
Value of products..........	$65,824,896	$128,421,585	$175,657,348

Ball-Bearing and Draft-Saving Utilities.

Importance of Bearings.—The placing of a small spherical piece of steel between the bearings of parts of machinery was an innovation that was widely welcomed when it was introduced a few years ago. This little device produced extraordinary results in controlling friction, in lightening draft, in prolonging the endurance of machinery and in arresting those microscopic deteriorations which penetrate all mechanical appliances where part rubs against part.

Utility.—Ball bearings have introduced a new feature and new possibilities in that mechanical construction where it is possible to utilize them. They are largely used in vehicles, and also are being largely used in machinery of all kinds and in mechanism, light and heavy, where their presence restricts friction and permits an easier movement of connected parts.

Economies Subserved.—A wide door has been opened by this simple mechanical device for the attainment of economies and the avoidance of disadvantages which have been the subject of anxiety and apprehension on one hand and the object of fruitless study on the other.

Draft-Saving Utilities. — Draft-saving utilities of various kinds, in addition to ball bearings, are now in general use on wagons and carriages and vehicles, which materially reduce the effort of animals or increase the load which can be carried with the same expenditure of force. The mechanical appliances for the production of ball bearings are of extreme nicety of construction, and represent an extraordinary degree of inventive ability and mechanical aptitude. These spherical pieces of steel are manufactured in machines with enormous rapidity and with infinitesimal exactness, the slightest deviation between different balls producing inharmonious action and friction, and tending to defeat the very purpose of their use. The industry has grown to large proportions, and is one of the most interesting processes.

Bells, Manufacture of.

Bells Long Ago.—Bells have been known from the earliest historical times. They are spoken of in Exodus in connection with religious worship, to which purpose they were for a long time restricted. The processes of manufacture in early times are entirely unknown. Small bells were attached to the robes of the Jewish high priests and had a symbolical significance. Golden bells were made in the earliest ages which would point to the fact that gold was known, used, mined and worked into various kinds of ornaments. Bells have been found near the site of old Nineveh, the alloy of which was 10 parts of copper to one of tin.

Growth of Manufacture.—The Greeks and Romans used bells in camps, markets and baths, as well as in religious observances. Bells were introduced into the churches in the Christian era as early as the year 400 A. D. They were manufactured through succeeding centuries and a bell became a very important adjunct of the early centuries and especially during the Middle Ages. They were in use in England in the seventh century, being imported from the continent.

Big and Little Bells.—Bells were first cast in England about the year 940. Sheep bells of bronze used in ancient Italy are still to be seen in the museum at Naples. It became the habit of the owners of cattle and sheep to attach small bells to them when turned loose to feed that they might be more easily found when wanted. Some bells of enormous size were cast at a time when facilities, such as we understand them to-day, were entirely absent. There is one bell at Amarapoora in Burmah which weighs 260,000 pounds, and one at Peking 130,000 pounds. Large bells were made in Russia, one at the Kremlin in Moscow, weighing, when recast, 432,000 pounds, the largest bell in existence. The great bell of St. Paul's Cathedral in London, cast in 1709, is 6 7-10 feet in diameter and weighs 11,470 pounds. Big Ben, of Westminster, cast in 1858, weighs 30,324 pounds.

Development of the Industry.—The development of the bell industry in the United States began when the colonists were few in number, but languished and did not assume importance until within sixty or eighty years.

The Great Stimulus.—The greatest stimulus imparted to the bell industry was given when electricity became a factor in modern life. The requirements of the electrical industry stimulated the manufacture of bells of tiny proportions, which perhaps do not belong strictly to the bell-making industry as it is generally regarded. The use of bells in churches, schools and other public edifices is declining in proportion to the amount of building done. The necessity for their use is declining with the increase of other means of noting time. The watch and clock industry restricted the bell industry in a material degree, rendering bells largely unnecessary, and where used, more a matter of ornament than of utility or necessity.

The Consonant.—Antiquarians have found small bells in the palace of Nimrod, and they were used for centuries in China before they were heard of in Europe. The bronze bells of Nineveh were made of 10 parts copper and 1 of tin. A good bell, when struck, yields one note, called the consonant. To test a bell, tap on the curve at the top, and it will yield a note one octave above the consonant. Tap it one-quarter lower down, it will yield a note the quint or fifth of the octave. Tap it half way down, and it yields a third-octave note. Tap it strongly above the rim where the clapper strikes, and the octave will sound simultaneously and yield the consonant.

Quality of Bell.—The quality of a bell not only depends on the casting and fineness and mixture of the metals, but upon the due proportion of metal to the calibre of the bell. The larger the bell, the lower the tone. It is calculated that for a peal of bells to give the pure chord of the ground tone or keynote, third, fifth and octave, the diameters are required as 30, 24, 20, 15, and the weights as 80, 41, 24 and 10.

Bell Founding in Holland.—Bell founding attained perfection in Holland in the sixteenth and seventeenth centuries. Bells were made with bas-reliefs of exquisite beauty, the striking being by hand, clapper and revolving drums. In past ages they had considerable influence on architecture, most towers being built to hold them.

Comparative Summary of the Bell Industry.

	1880	1890	1900
Number of establishments....	20	22	23
Capital invested............	$793 120	$590,420	$1,038,305
Wage-workers...............	773	372	663
Wages paid.........	$280,169	$193.780	$307,991
Value of products...........	$1,065,824	$323,010	$1,247,730

Belt Makers and Belting.

Early Belting.—The discovery of the steam engine created the necessity for belting. As a means for the transmission of power it answers a requirement for which, until recently, no acceptable substitute had been found. The first effort to utilize belting was extremely crude and yet it accomplished work. It consisted of strips of skin sewed together and made sufficiently taut to turn a wheel. The utility of these crude belts was at once recognized by mechanics and their use extended rapidly. There are hints and allusions through the writings of earlier historians of belting being used in the conduct of manual operations, but the information is too hazy to warrant positive statements concerning it. It was not until mechanical devices began to be used that belting assumed any degree of value. In a short time the manufacture of belting became quite a little industry and it has been growing in use ever since; in recent years the genius of mechanics and of inventors has been addressed to the great problem of dispensing with it wherever it is found possible. Considerable progress is being made in this direction.

Use of Leather.—Leather, from its strength, pliability and durability is up to the present time the best known material for all ordinary belting requirements. This assertion may, perhaps, seem too sweeping in the estimation of many manufacturers of excellent substitutes, which have endured the test of severe mill and factory work for many years. For extra wide main driving belts, vulcanized India rubber is preferred by many. It has advantages over leather, of lower first cost and greater driving power. Observing mechanics, however, question whether the difficulty of repairing such belting by unskilled hands constitute it the best in the long run. Good driving belts are made of cotton, folded and sewed together longitudinally, and saturated with some oily composition. They grip the pulleys well.

Ox-Hide Belts.—The strength of ox-hide belts used for belting has been calculated at about 3,086 pounds of square inch of section. This is reduced at the riveted joint to 1,074 pounds and to 960 pounds at the laced joint. One-third of these figures may be given as a safe working tension for transmitting power in high-speeding machinery, and belts should be made about one-third wider than for slow speed. It is desirable to make all belts even thickness and have them neatly joined. The driving pulleys should be accurately turned and rounded on the face. For joining belts, hooks, malleable toothed, plated and other devices have been used, but plain lacing is generally preferred. Endless driving bands, formed of crucible steel wire woven into a network for chain, are used where the wires are arranged to run parallel to the width of the belt. They possess great flexibility and driving power. These bands are also constructed with leather or elastic lining to prevent stretching.

Softness and Pliableness.—The users of machine bands know by experience that belts stuffed with tanner's dubbin on the flesh side will become as smooth all over as the hair side and will outlast many belts which run on the hair side only. Very much more adhesiveness is gained by softness and pliableness of belting leather over those which are dry.

Peculiarities of Belting.—Long belts are preferred to short ones. Horizontal, inclined and long belts give a much better effect than vertical or short ones. Belts of coarse, loose leather do better service in dry, warm places. The hair side of a belt put next to the pulley will drive, perhaps, one-third more than the flesh side. The strongest part of the belt is near the flesh side and about one-third the way through from that side. Leather belts should be well protected against water or moisture. Short belts require to be tigher than longer ones. A long belt working horizontally increases the tension by its own weight, acting in a curve formed between the pulleys.

Characteristics of Belts.—Belts are too often run tense, to their injury, and unnecessarily wear the bearings. Lace-holes sometimes tear out because the belt is too short. To obtain the greatest power from belts the pulley should be covered with leather. Friction on wood is considerably greater than that on cast iron. Long belts are less liable to slip than short ones. Softer woods are better suited for pulleys than harder woods. Measures for tightening pulleys should be applied to slack side of belt. Belts should be cut from the center of the skin; thickness of belt does not always mean strength; in punching a belt for lacing an oval punch should be used, the longer diameter being parallel to the belt.

New Devices.—There is a gradual modification in mill, shop and factory equipment, the objective point being to utilize power for the various purposes of the shop independent of its conduction by belting. Electrical power and appliances are introducing to some degree new methods, and in the opinion of some engineers, are gradually working a transformation. Belting necessarily must hold a place in the shop, but as the science of mechanism and a more thorough knowledge of the economic application of electric power grow, leather belting, some mechanical engineers believe, will find a narrowing field. The important economic advantages which experience has already demonstrated as resulting from the division of power will stimulate further efforts in methods of power transmission, independent of belting. The effort to utilize electric energy, to localize the application of power where the work is, instead of carrying the work to the power is bound to have a very important influence upon shop management and shop economy. It promises to revolutionize, in no small degree, the system of fly-wheels and immense engines and boilers and extensive and expensive shafting and belting and all the long list of lesser appliances which are involved in that cumbrous method of power transmission.

Inventive Talent.—Inventive talent and ingenuity are at work to change old methods along all mechanical lines. The factory, with its system of belting, is now on trial, as it were, and whatever cannot stand the test of the highest inventive skill of the aroused intellect of man will be consigned to the scrap heap. American mechanical ingenuity is teaching the world the advantage of new methods and systems and the disadvantages of old methods, and is demonstrating the fact that important economies await the introduction of the finer products of mechanical skill. The comparative silence of the machine shop and factory of to-day, operated by the invisible power of electricity, coupled with the cleanliness and comfort, stand out in bold comparison with the noisy and ill-arranged shops of the past. While mediæval palaces are crumbling into ruins, industrial palaces are arising, which represent in their construction and equipment the spirit of progress which is now transforming the world of mechanism from crude methods into refined, and which are more economical, and productive of vastly more important results.

Comparative Summary of the Leather Belting Industry in the United States.

	1880	1890	1900
Number of establishments...	96	93	105
Capital invested............	$2,748,799	$4,973,420	$7,410,219
Wage-earners................	1,227	1,342	1,667
Wages paid..................	$606,087	$780,615	$913,937
Value of products...........	$6,525,737	$8,633,634	$10,623,177

Billiard Tables and Materials.

Origin of the Game.—The game of billiards is said to have been invented in 1371 by a French artist, though Italy claims whatever distinction there may be involved. As is known, it is played on a level, smooth and rectangular table, on which ivory balls are used, driven by a tapering stick called a cue, according to certain established rules. The billiard tables are largely found in hotels, though a billiard-room has latterly become a feature of many private mansions. It is regarded as a healthful game, in that it rivets attention of the players and involves physical movements and locomotion which afford moderate exercise to the muscles.

Interest Lessened by Other Sports.—It would appear, from a study of the industry, that the development of indoor as well as of outdoor sports has detracted measurably from the interest heretofore felt in the game. The bicycle, and later the automobile, together with golf and other games, seem to have opened up more desirable avenues for enjoyment and relaxation.

Care of Billiard Tables.—The cloth should be brushed each time the table is used, and when not in use, covered. It should be brushed with the nap or grain. Cushion bolts should be screwed up tight at least once a month. Keep the cues in a perpendicular position. Don't let the leather project over the point of the cue. In new cues the leather is liable to spread over the point and cut the nap of the cloth. Keep cues well tipped, by having large-sized, good-quality tips and cue clamps in the billiard-room. Ivory balls are constantly getting out of round. Send all suspected ones to the maker to be put in order. Use furniture oil polish to keep the woodwork fresh. The table should be overhauled at least twice a year.

How to Set Up a Billiard Table.—All parts of the table are numbered. Place the legs in proper position on the floor, screw the sides and ends into them. See that the tenons of the rails are well down in the mortise, taking care to put a piece of wood on the top of the rail to keep it from being bruised with the hammer. Next put in the stretcher rail as marked. The frame must then be leveled by putting pieces of wood of requisite thickness under the level until a spirit level and a straightedge show a perfect level across the length and width of the table. Find the highest part, and level up to that. Next put on the slabs of slate, which must be screwed down all around the edges first and leveled again with a spirit level and straightedge. Next the screws in the middle are to be inserted and screwed perfectly tight. Then fill up the screw-holes and joints with plaster of Paris mixed to the consistency of cream and put on quickly, taking care to scrape the filling stuff perfectly even with the bed. When thoroughly dry, the hole must be made smooth with sandpaper.

The Cloth.—Next put on the cloth, and have the grain run from the head of the table. Draw it tight, and avoid wrinkles and creases. Tack the cloth for a few inches at one corner, then pull the cloth tightly to the corner at the other end of the table, same side, putting in a few tacks to hold it while the whole of that side is being tacked. Put the tacks about 2½ inches apart, and then proceed the same way on the opposite side, pulling the cloth evenly and as tight as possible without tearing it. Then tack the head and end of the table in the same manner. Screw the chalk cups on the rails before they are put on the table, then put on the cushion rails as they are found to be numbered. Before screwing the cushion rails tight, put in the pockets and screw the iron pockets in their places, then screw up the rails as tightly as possible and tack the pockets and leathers in order. In a carrom table the four corner cushion bolts are put in first and screwed up to bring the cushion rails properly together. Then put in the other cushion bolts. In placing the spots, draw a line down the middle of the table from the center sights in the head and lower cushions. Then draw two lines from the second sights in the side cushions, and where these lines intercept place the spots. The pool spot is placed about 5 inches from the lower cushion on the central line. Spots are made from court plaster; wet and hammer them on lightly. The light used should be about 3½ feet from the bed of the table, which means 6 feet 2 inches from the floor.

Late Improvements. — Among recent improvements may be mentioned doweled slate beds, iron bolt corner sections, iron leg bolts, rosewood veneered cushion rail tops and patent cushion rail bolt caps. The usual outfit consists of 1 dozen fancy-butt cues, assorted weights; 1 cue rack, 1 set of three 2⅛-inch ivory billiard balls, 1 marking board, 5-foot bridge, 1 extra long cue, 1 smoothing iron with shoe, and 1 billiard tip clamp.

Statistics.—While the number of billiard table manufactories increased in number from 46 to 75 since 1880, the values produced fell from $2,289,758 to $1,650,868, and the number of workmen engaged fell from 857 in 1880 to 455 in 1900. Capital invested also materially declined.

Blacking Manufacture.

Common oil blacking is a mixture of ivory-black or lamp-black with linseed oil or often with small-beer or water, with a little sugar or gum Arabic. Florence oil, molasses and sulphate of iron are sometimes used. Blacking is considerably used in the industries, but its larger and more familiar use is as a polish for footwear, for which use the product has been improved up to the highest chemical possibilities. It is a very old industry in the United States, one of the oldest houses, established over a century ago, being still in business. During the past twenty years the number of establishments has grown from 48 to 121, the number of wage earners from 436 to 1,250, and the value of products from $1,491,474 to $4,504,965. One method of making liquid blacking is, take 2 pounds of ivory black in fine powder, 1½ pounds treacle and ¼ pint sperm oil; rub the black and oil well together, add the treacle and mix. The cheapness of blacking, however, renders its special preparation unnecessary.

Blacksmithing and Wheelwrighting.

The Blacksmith.—The importance of the handicraft of blacksmithing and wheelwrighting is shown in the fact that there are 5,771 blacksmith establishments in the United States whose work in the year 1900 was valued at $85,791,630. These figures include all machine blacksmithing work. The growth of blacksmithing is shown by the fact that the value of work done in 1880 amounted to $62,667,129. In that year over $16,000,000 was paid in wages. In the next twenty years the increase in value of products amounted to about 30 per cent. while the increase in the total amount of wages paid was about ten per cent. by reason of the remarkable increase in machinery, tools and shop appliances. With the general introduction of machinery the blacksmith became a very important factor in industrial society. Formerly the work of the blacksmith mainly consisted in forming a horse shoe and in shoeing horses. The rapid development of mechanical appliances brought out a new type of blacksmith termed the "machine" blacksmith, whose work consists largely in the manipulation of iron and steel with forge-fires for fabrication into numerous mechanical devices. With the introduction of the power hammer and a score of patented labor-saving devices the range of the smith's work has been largely extended, and has become more intimately related to the manufacture of machinery. It is from this point of view that the importance of the blacksmith and his craft are to be considered.

Higher Qualifications.—Formerly the education of the blacksmith was restricted to a few important essentials; with the general introduction of iron and steel, and the necessity for its careful manipulation under varying conditions and for a greater variety of purposes, it became necessary for the blacksmith to become, to some degree, a machinist, and to acquaint himself with the character of the metals and their usefulness under the varying conditions of manufacture. The art of welding became an important one, and the art of hammering, apparently a very simple matter, called for an intimate acquaintance with the nature of iron and steel and an exact judgment in their manipulation.

Range of Work.—Where formerly the art of the blacksmith was confined to the production of a few articles, to-day the range of blacksmithing is as wide as the industrial requirements for welding, heating, hammering, tempering and the various manipulations demand. A large portion of the blacksmith's time is spent in welding. Upon its character depends in great measure the wear and strength of the work.

Managing the Fire.—A perfect weld, the smith learns, cannot be made if any foreign matter comes between the two parts to be united. Defective welds result in accidents and loss, and much loss is due to overheating or not enough heating, to a green or new fire or a fire full of cinders and dirt. A good smith will not use a tool of any kind on his irons after they are welded until he cleans the scale from them. A smith's skill is tested especially in carriage and wagon blacksmithing. Beginners make the mistake of pulling the irons out to see if they are hot enough. The color of iron at a welding heat depends in a measure on the quality of iron and coal used.

Case-Hardening. — Case-hardening consists in the conversion of the surface of wrought iron into steel, and it is usually from one-sixty-fourth to one thirty-second of an inch deep. The simplest method is to heat to red heat and apply powdered prussiate of potash. The secret of success lies in crushing the potash to a fine powder, rubbing it well on the work, so that it fuses and runs freely. The first requirement of case-hardening is that the articles be well polished. There are a great variety of methods, all of them requiring particular care.

Box-Hardening.—Box-hardening is sometimes used, which consists in packing the articles in a box inclosing the case-hardening materials. The box is made air-tight, its seams being well luted with fire-clay. A better material is composed of leather and hoof, cut into pieces about an inch in size, to which may be added three layers of salt, in the proportion of 1 pound of salt to 5 pounds of leather and 3 pounds of hoofs, adding about one gallon of urine after the box is packed. This is placed in a furnace, which is continued at a red heat for twelve hours, when the articles are taken out and quickly immersed in water.

Finding the Length of Axles.—To find the length of axles, measure from the back end of the hub to the face of the spoke, then double the length and subtract it from the width of the track in which the vehicle is to travel. Another way is to take the distance of the track from center to center, and establish the length of the axle so that the hubs are the same distance apart, less the length of one hub.

The Gather of Axles.—The use of the gather of axles is the necessity of overcoming the throwing out of the forward edge of the wheel by the springing of the axle, one-sixteenth, or at the outside, one-eighth of an inch difference between the front and back of the felloe being all that is required. The principle is to have the rims described by their tread on the ground absolutely parallel lines at perfect angles with the axle bed, and no wider than the true width of the tire. In proportion as the wheels deviate backward or forward from these lines the draft is increased.

To make a wagon run easily, set the axles so that the faces of the spoke will stand plumb—i. e., so that the width close under the hub and the track on the floor will be the same.

Interior Arrangements. — Much attention is being paid these days to the interior arrangement of a blacksmith shop with reference to forges, anvils and benches. There is much to be gained by a proper arrangement, and many of our modern blacksmith shops are models of excellence in this regard.

Tools.—Blacksmiths' tools are many in number; not all shops are properly equipped. Among the tools essential are dividers, T-squares, tongs of all kinds, sharpening chisels, hot, cold and gouged chisels; square chisels, punches, cupping tools, swages, top and bottom fullers, tools for making heads or nuts, tools used in making clips, anvils, forges, jaws, drills, rivet-cutters, bolt-clippers, dies, hooks, turnbuckles, appliances for welding, and too many other devices and equipments for enumeration.

The blacksmith has to learn the importance of heating steel as quickly as possible and securing an even degree of heat all through the part to be forged and heating other parts as little as possible.

Hardening Tools.—In tempering taps, reamers, twist-drills and other like tools great care should be taken to put them in the water in a perpendicular line and slowly, not allowing them to remain stationary in the water. For removing scale from steel when put into water, ivory black can be used, putting it on the steel while it is heating and letting it remain until the steel goes into the water. To insure thorough hardness, salt should be added to the water until it becomes quite brackish. The salt will cause the water to take hold of the steel and cool it off gradually.

Dies and Punches. — The best way to harden trimming dies is to examine the die thoroughly before it is dipped, and turn it while dipping so that all the thick or heavy parts enter the water first. The best method of hardening punches is to harden them first in cold water and then draw the temper to suit the work intended. While the die is hanging in the tub it would do no harm to pour water on the bottom of the die, which is out of the water.

To select good tool steel many blacksmiths break the bar and observe the grain, which presents a silvery look; but this is a test which is liable to be unsatisfactory.

Swaging.—The old method of forging a swage was to roll up a piece of band iron to make the body of the swage, and then weld a face of shear or double-shear steel on it. In modern practice, however, solid steel swages can be purchased at less cost than they can be made.

The Principle on Which Edged Tools Operate.—A chisel is a wedge in one sense, as well as an axe, drawing-knife or jack-knife. When a wedge is dressed out smoothly it may be driven with much less force, as every mechanic knows, than if its surface were jagged and rough. The same applies to edged tools. By keeping edged tools ground smooth and true and neatly polished, a tool does its work with much less force than otherwise. All edged tools that are operated with a crushing instead of a drawing stroke, should be polished neatly to the clear cutting edge.

Care of Tools.—Some blacksmiths use French polish to keep the wooden parts of their tools in good shape. A better plan is to let them soak in linseed oil for a week, and then rub well with cloth a few minutes a day for a week or two. A solution of India rubber in benzine has been used for years as a coating of steel, iron and lead, and it has been found sufficient to keep them from oxidizing. All steel articles can be perfectly preserved from rust by putting a lump of freshly burnt lime in the drawer or case in which they are kept.

Theory of Welding.—Blacksmiths should become familiar with the melting point of metals, solders and fusible compounds, in order that they may do welding, brazing and soldering intelligently. They should also study the theory and the practice of welding, for without a knowledge of the theory they will find themselves in the dark. The theory of welding is simple enough, but it requires a little thought to do the work right. Bessemer steel tires may be welded almost as readily as iron with ordinary borax flux. They can also be welded by putting good iron filings between the scarfs and avoiding heating too much. Cast iron can be welded by heating it nearly to the melting point on a clear fire free from dirt, and hammering very lightly; but this job requires practice and care. Malleable cast iron may be welded together or welded to steel or iron by the same process that two pieces of steel are welded, but it takes several experiments to succeed.

Malleable cast iron plates can be welded by riveting them together and using a flux of powdered borax and Norwegian or crucible steel filings, equal parts.

Some smiths think the more sand they can get on in welding, the better; but this is a mistake. A good soldering fluid is made of 2 ounces alcohol, to which a teaspoonful of chloride of zinc is added and shaken until dissolved.

Experiments have demonstrated that the greater part of the hardness of steel depends upon the quickness at which the temperature is reduced to the proper limit, provided proper skill is used.

It would be impossible to educate the blacksmith in a few pages, but the above simple rules and suggestions, if observed, will simplify his work.

Blowpipe Welding.—A process for the seamless welding of iron or steel and other metals from the heat of a union of acetylene and oxygen, is the latest surprising advance in welding. The ignition produces an extraordinary intensity of heat, which can be centered into a heat zone of about one-eighth of an inch in length, which reduces any metal brought into contact with it, even quartz, to a molten state. The operation can be conducted with the naked eye. The process can be applied to all kinds of welding.

One important work of the old-time blacksmith was to make horseshoes, which was a slow, tedious, difficult operation. This method of providing horses with foot protection was brought to a termination by machine-made horseshoes, in which industry Henry Burden, of Troy, N. Y., took the lead, making horseshoes on a large scale. Nearly 400 patents have been granted for horseshoe machines. The industry, though a minor one, is prosperous and has effected a great revolution in the shoeing of horses and in the great saving of labor.

Comparative Summary of the Blacksmithing and Wheelwrighting Industry.

	1880	1890	1900
Number of establishments..	38,802	28,000	51,771
Capital invested............	$30,259,932	$34,500,139	$54,976,341
Wage-earners...............	50.624	26,539	36,193
Wages paid.................	$16,200,800	$13,499,738	$17,974,264
Value of products...........	$62,667,129	$54,304,639	$85,791,630

Bleaching Materials.

Their Manufacture.—Bleaching materials, so essential in textile productions and paper making, of various kinds have been in use from time immemorial, and frequent references are made in the books to their diversified utilities. With the introduction of electricity as an agent in effecting chemical transformation a great advance was made. Common salt and other chlorides are being electrolized on a commercial scale, the chlorine thus produced being converted into bleaching powder by means of lime; other hypochlorites are made from imported bleaching powder.

Field for Electrolytic Processes. — One great field for electrolytic processes is the producing of bleaching liquors and caustic solutions for bleacheries, paper mills and the like. Large economies have been introduced in recent years. There are 26 factories producing bleaching material, employing 216 workmen, with an invested capital of $700,000.

Use of Sulphur.—Sulphur dioxide was used as a bleaching agent in ancient times, and was made by the burning of sulphur in air or oxygen in the presence of water; it bleached wool, hair, straw and other tissues, but the bleaching was not permanent. It is also used as a disinfectant or germicide as well as in ice machines as a refrigerating agent, in the preparation of bisulphite, in the leather and glucose industries and in the manufacture of sulphuric acid. It is largely used in the sulphite process for converting wood into wood pulp for the purpose of making paper.

Bisulphites.—Bisulphites of sodium, calcium and potassium are manufactured by saturating a solution of sodium carbonate, milk-of-lime or potassium carbonate with sulphur dioxide, and crystallizing out the salt formed. These products are employed as anti-chlores in bleaching, to remove the excess of chlorine from the fibres of the goods which have been bleached by hypochlorites, thus preventing the chlorine from rotting the fibre. They are used to treat wood pulp in making paper, also in chrome tannage, in brewing, in glucose and starch making as preservatives.

Hydrogen Dioxide.—Hydrogen dioxide is a powerful oxidizing agent, and is used in bleaching hair, silk, wool, feathers, bones and ivory. It is quite extensively used for toilet purposes and as an antiseptic and disinfectant in surgery, as an anti-chlore, as a reducing agent in chrome tannage and as a preservative for milk, beer, wine and other fermentable liquids.

Sodium Dioxide.—Sodium dioxide consists of two parts sodium and two parts oxygen. It is chiefly used as a bleaching agent, and is a very powerful one, giving off 20 per cent. of its weight of active oxygen. It is too strongly alkaline for silk or wool bleaching, and for this purpose is converted by adding a solution of magnesium sulphate. Bleaching materials form the basis of one of the most important industries in the United States.

The industry of bleaching received a tremendous impulse with the general introduction of cotton as material for textile manufacture, though all fibres are readily subject to this action, partly mechanical and partly chemical.

Bleaching Calico.—One method of calico bleaching on a small scale is to boil the material to be bleached in a strong solution of caustic soda, then thoroughly rinse in clean water, steep for half an hour in a strong solution of chloride of lime in water, wring out and pass through water containing 3 per cent. sulphuric acid, and finally rinse thoroughly in running water.

Bleaching Cotton.—Make a solution of chloride of lime in water; let settle and draw off the clear liquid. Rinse the goods in water containing 5 per cent. sulphuric acid and pass slowly through the bleaching solution.

Bleaching Jute.—Make a solution of 5 pounds soap at 140 degrees Fahr., and pass the jute five times through it and rinse in clean water. The process of exposing vegetable fibre of any kind to sun, air and moisture is known as "crofting" or "grassing," and the process of boiling with alkali and soap is known as "bowking."

Bleaching Silk.—The material to be bleached must be excessively clean. A bath is made of peroxide of hydrogen with a trace of soda lye. The silk is simply laid in this liquid and left to steep. Sunlight, or a moderate heat, assists, and the process continues from two to fourteen days. It is then rinsed in condensed steam water.

Blowers and Furnace Feeders:

Draft Appliances. — For the production and utilization of power, various mechanical draft appliances have been perfected and introduced in manufacturing plants. The tubular boiler has superseded the original plain tank of boiling water and the water-tube boiler. Next came various draft-improving devices as substitutes for chimneys, and at less cost. With these mechanical appliances the draft is regulated so as to burn all the carbon of the fuel, which cannot be done by natural draft.

The temperature in the combustion furnace is 1,000 degrees higher than where natural draft is used, which is a self-evident advantage in securing the highest possible efficiency in combustion.

Installation.—These plants are easily installed, are instantaneous in action, and provide a constant boiler pressure. The essential features of the apparatus are the furnace, the boiler, the fan and means for conveyance of the induced draft. The objects to be gained are greater combustion of fuel, use of less fuel, saving of cost of high chimney, greater and more controllable power, and increased boiler power.

Equipment.—In some plants two fans are used, one to draw in, another to expel the air. The simpler equipment consists of the one-fan arrangement, where the fan has two inlets, with connection with the chimney flue or smoke breeching of the boiler, which takes in the flue gases. These are mixed with fresh air as it leaves the outlet and is delivered to the ash-pit of the furnaces. From thence the air is forced through the grates to the fuel bed. The favorite point of introduction into most boilers is through the bridge wall at the rear end of the grates or through the side walls. The more complete steam plants of to-day are equipped with mechanical stokers.

To obtain the greatest advantages of mechanical draft, the fan or fans should be provided with direct-connected engines, on account of the perfect control and regulation thus obtainable, and their entire independence of any outside source of power. Thus the fan may be started before the main engine in the morning, and in a very short time get the fires in the right condition to carry the load.

Forms of Draft. — Application of mechanical draft assumes three general forms: First, induced draft by the installation of fans to serve as a chimney; second, forced draft by applying fans to force air beneath boiler grates; third, the combination of induced draft and forced draft obtained by fans applied to serve both purposes, or by separate fans for each. Many large plants are now installed where this combination is employed, the combined forced and induced draft system being brought about on account of equipping the boilers with any make of stokers outside of the chain type or those having the open ash-pit. Air, under a pressure of from 1¼ to 2 ounces, is delivered to the stokers by a forced-draft fan, the separate induced-draft fan or fans being connected in the ordinary manner with the boiler breeching, with or without economizer in connection, and discharges the gases through a steel stack into the atmosphere.

Natural Draft.—Natural draft requires that the gases in the chimney be above a certain minimum temperature, in order to secure a proper supply of oxygen in the furnace and good combustion of the fuel; whereas, with mechanically induced draft, the amount of draft obtainable is entirely independent of the temperature of the flue gases, and when used in combination with a properly proportioned economizer, it is possible to lower their temperature to a point where the draft of even a very tall chimney would be practically destroyed. Mechanical draft possesses great advantages over natural draft in its flexibility and adaptability to both large and small capacities, and in its ability to meet sudden and excessive demands for steam, either by an extra turn of the throttle valve or by an automatic regulator controlling the steam supply to the fan engine according to the boiler pressure. It is unaffected by atmospheric changes, furnishing the desired amount of draft irrespective of conditions of wind or weather. Operating independently of the amount of heat in the stack, it is possible to obtain a higher temperature of feed water in the economizer and a lower temperature of escaping gases than could possibly be obtained with a chimney, and at the same time provide sufficient draft to maintain rapid and economical combustion of the fuel. A mechanical-draft plant, properly designed, with duplicate fans and engines of suitable construction, so arranged that one is always in relay, can be made so reliable that the boilers cannot be shut down by an ordinary accident. With the fans properly designed and proportioned to the work, the power required to operate them is so small as to practically have no effect on the economy obtained.

Induced Draft. — Induced draft affords the greatest benefits of economizers, as the system is especially adapted to this end. Other features in favor of the system are in the line of convenience and saving of labor in operation and installation. No changes are necessary in boiler settings, such as introducing dampers or air ducts. The draft being more uniformly distributed over the grates, the fires require less attention to make them burn evenly. There is less deposit of soot in the boiler tubes, on account of the higher velocity of the gases passing through. This makes frequent cleaning unnecessary. Free access may be had to the ash-pit or to the fire-box without blowing out into the room, since pressure is inward rather than outward. For the same reason there is no deposit of dust and fine ash in the boiler-room, which may occur with forced draft if the boilers are not air-tight.

The possibility of loss is often greater with chimney draft than with mechanical draft. During the years 1900 and 1901 especially, the wind storms in various parts of the country played havoc with the stacks, which were laid low, causing much damage to adjoining buildings as well as their own total loss.

With mechanical draft the rate of combustion can be easily increased to over 50 pounds of coal per square foot of grate, driving the boiler at more than double its rated capacity with fair economy. Of course, it should be understood that such high rates of driving are possible, even for short periods, only where the boilers are in the best condition, with ample heating surfaces free from incrustation and designed to withstand high temperatures.

To show the increase in efficiency that may be obtained by decreasing the amount of grate surface and increasing the rate of combustion correspondingly, for example take a boiler having a ratio of heating surface to grate surface of 30, which, at a rate of combustion of 21 pounds of coal per hour per square foot of grate surface, will give a performance of .146 B. H. P. for each square foot of grate surface at a thermal efficiency of 73.6 per cent. Now, if the grate surface be decreased one-half, we will have a surface ratio of 60. To obtain the same performance of heating surface we must maintain a rate of combustion of 35.9 pounds of coal per hour per square foot of grate, which should give us, under average conditions, an efficiency of 77.9 per cent., or an increase in efficiency of 4.3 per cent. As a more striking illustration, take a boiler with a surface ratio of 30, which should give, under proper working conditions, a thermal efficiency of 76.5 per cent., at a rate of combustion of 15 pounds of coal per hour per square foot of grate surface, and a performance of .10 B. H. P. per square foot of heating surface. Let the grate surface be decreased to give a surface ratio of 46, then, by increasing the rate of combustion to 30, we shall have increased the capacity of the boiler 46 per cent. without having decreased its efficiency.

Bluing, Art of.

Variety of Solutions.—The art of bluing, which is so extensively practiced in calico printing, is based upon long experience and analytical study of expert chemists and manufacturers. The methods of preparing the various solutions and their application to goods form an interesting chapter in the development of one branch of American textile manufacturing. Indigo effects are numerous, under which come China blues and designs in blue on a white ground. To produce pale-blue patterns on a deep-blue ground, the entire pieces are first dyed in a light shade in the vat, then withdrawn, washed, taken through vitriol sours, washed again, squeezed and dried. One of the white reserves is then printed on, the pieces are returned to the vat and dyed with a darker shade; the reserved parts appear as a deep-blue pattern on a deep-blue ground.

The bluing process is fundamentally the same, and consists in the preparation of such solutions by well-known ingredients which, when brought into contact with the goods to be acted upon, impart through both chemical and mechanical action the desired shade. The dyers have many rules and processes for the making of solutions which form the basis of an interesting and valuable department of textile literature.

Statistics.—The number of establishments engaged in making bluing increased from 23 in 1880 to 65 in 1900, and the value of products from $344,824 to $575,804 in 1900.

Bone, Ivory and Lampblack Industry.

Bone and Ivory Ornaments.—Bone and ivory have been in all ages decocted or turned or ground into more or less artistic shapes for personal use or adornment or for household ornaments. Remarkable skill has been developed among some people, especially East Indians, Chinese and other less advanced people, in the manipulation of these materials.

Preparation.—Ivory and bone admit of turning, filing and polishing to a high degree. Fine glass-paper is used for polishing, after which a finish may be given by the use of pumice powder. The final polish may be given by washed chalk or fine whiting. The greatest care is necessary in the preparation of ivory for painting. Defects on the surface must be removed by use of the most delicate powders carefully applied. The surface must present one uniform tint or the painting will be defective. It must not, however, appear polished. The final step is to apply a little cuttlefish powder, after which wash the surface of the ivory with a camel's-hair pencil and water, and it is ready to receive the colors.

Ivory black is a beautiful pigment prepared by carbonizing waste fragments and turnings of ivory.

Lampblack. — Lampblack is an exceedingly light, dull-black powder, formed by the imperfect combustion of oils, fats, resins, etc. Lampblack is obtained in various ways. Its particular virtue as a pigment lies in its condition of extremely fine division, which could not be attained by other means. This quality renders it invaluable as the basis of black pigments, all of which contain it in greater or less quantity. Indian ink and printers' ink are composed principally of this substance.

Statistics.—In 1900 there were 15 establishments producing these pigments, representing an invested capital of $782,247 and a product worth $359,787. In 1890 the value of the output, according to census figures, was $1,031,030.

Book-Makers and Binders.

The Early Book. — The earliest known specimens of bookbinding were the joining of two tablets of wood, usually beech or fir, their inner sides being coated with wax on which letters were traced with a stylus. These tablets, when joined, were called "diptychia," and they were fastened together at the back by the early Roman bookbinders. Prior to that time, records were variously preserved, often on boards, clay slabs or various materials, and on parchment, which was wound into rolls. The pages in these early Roman books were called cerve, and had a raised margin which prevented friction of wax. Paper in ancient times was made from the concentric coats which inclosed the stalks of the Egyptian papyrus, which, when gathered, measured from 8 to 12 inches. These sheets were written on with reeds dipped in gum water colored with charcoal, soot or resin.

Book Paper. — Waxen tablets continued down into and through the Middle Ages. The oldest extant specimen dates from the year 1301, and is now in the museum at Florence, Italy. Palm leaves then came into use, and the inner bark of the lime, ash, maple and elm was also used. The first substitute was the skin of sheep or lambs, and this parchment began to supersede papyrus in the seventh century. Paper made from cotton came into use early in the tenth century, and this saved much of the destruction of the old parchments.

Invention of Linen Paper.—An epochal event in book making was the invention of linen paper about 1270, though very little was used until the fourteenth century. The early books were called rolls, which were rolled on a staff. At first letters were divided only into lines, afterward into words, and subsequently to this, punctuation was adopted as a matter of convenience and easy reading. The sizes of the early books were known as "royal," "demy" and "crown."

Bookbinding.—Bookbinding in the days of the Roman Empire, and especially in the Middle Ages, was the work of monks. The general aspect of monastic binding was thick, heavy and solid, and, according to modern ideas, clumsy. Books for common use were inclosed in boards covered with leather, with binding protected with metallic bases, corner plates and clasps. Ecclesiastic and royal literature was inclosed in ivory sides, with artistic carving enriched with gold, enamel, gems and jewels. At the period of the Renaissance, silk and velvet were liberally used for ornamental binding. Ivory and medallions are as old as the sixth century.

Ornamental Binding.—A new and revolutionary era dawned when printing was introduced. The old massive boards, with their bosses, corner plates and heavy clasps, disappeared, and the sides covered with leather, parchment and vellum came into use. Binding with enamels, metals and gems fell into disuse, and richly covered vellum, with elaborate designs blind-tooled or worked in gold or color, came in. Subsequently the taste for magnificent binding grew into a passion in France, but after a few decades disappeared. Bookbinding in England was stimulated by Roger Payne in his day, who introduced many methods which were long afterward followed. Charles Lewis was the next genius who made his name famous for fine book work, but the industry was limited to the requirements of those who could afford to indulge expensive tastes.

Modern Book-Making. — It was the spread of Christianity that gave the first genuine stimulus to book-making as "books" were then made. The selling of books as a distinct trade was established in Paris in the twelfth century, but modern book-making began with the discovery of the art of printing, and from that time downward the industry has grown in magnitude and in its influence on civilization.

The Spaniards did much more than they have ever been credited with in introducing book-making on the American Continent. Many of the scholars of Southwestern Europe followed them to the New World. The early presses of Mexico produced many publications, mostly of a religious character, and books were known there before Plymouth Rock had a name. Book-making and selling were introduced into New York in 1673, in Boston in 1674, and in Philadelphia in 1683, but most of the books then sold were imported.

Stimulus to Book-Making.—After the War of 1812-15 a new stimulus appears to have been given to book-making. The American book-maker began to reproduce many of the leading works of Great Britain. In later decades the industry has assumed phenomenal proportions, being stimulated by the popular demand for all kinds of literature, the basis of which was the public school system and that natural expansion of intellectual capacity which is incident to the conditions of free institutions. The book-maker has undoubtedly contributed more to the education of the masses than any other single influence, not excepting public schools. The schools cultivated the youthful mind in the elements of education, while books enabled the adult mind to broaden and deepen.

Bookbinding To-Day. — Bookbinding of to-day is characterized more by its cheapness than elegance, and the speed with which it is done. In fact, much binding is a mere delusion, but it is so in response to an urgent public demand. The various operations in book-making may be covered as follows: Forwarding, sewing the back, sewing and finishing. Leather and paper constitute the usual covering. When the back and corners are leather-protected, the book is termed half-bound. Binding is variously designated law, calf, morocco, paper, etc.

Mechanical Devices in Book-Making.—Previous to 1825 new books were usually issued in board covered with drab paper. The rotary cutting machine, or "ripper," proved to be a valuable adjunct to the bookbinder. The "smasher" is similar in its action to the embossing press. The cutting of three edges with one descent of the knife was another device which found quick adoption. Another machine of wide use has a revolving table, on which each edge of the book is in succession drawn in a standing direction up against a fixed cutter. The edges are gilded as in ordinary binding, and many are cut at once.

Trimming Machines.—The machines for trimming and gilding are various, and many improvements have been made on the means introduced by Cope and Bradford in 1865. The old process invented by William Hancock in 1836, which dispensed with sewing and coated the backs with India rubber, has been greatly improved. Cloth casing, while suitable for much binding, has been largely supplemented by more secure and workmanlike binding on books for public libraries and the like.

The Twofold Tendency. — There is a twofold impulse in the trade of bookbinding — one to cheapen work and the other to produce more substantial and artistic work. The multiplication of libraries, public and private, has given rise to the latter tendency, and it is aided by the almost human intelligence of the mechanical appliances which are introduced into almost every conceivable process of work. The specialization under which the industry is now passing promises in a very few years to result in the establishment of a class of artistic work equal in many respects to the splendid work of the earlier years of bookmaking.

Recent Improvements. — Among recent advances in bookbinding may be mentioned feeding devices for folding machines as well as for printing presses. Three-fourths of the folding machines in use to-day are supplied with automatic feeders, many of which have parallel-fold arrangements and automatic pointing devices.

Wire Stitching.—The wire-stitching machines have been successively improved. Some of these machines will stitch anything from two sheets to a book two inches thick, and with several of them either round or flat wire may be used. Among the more recent improvements is a combination folding and wire-stitching machine, which by continuous and automatic operation takes the sheets from the feeders and folds, gathers, collates, covers and wire-stitches copies of magazines and pamphlets, and delivers them ready for distribution.

Paper-cutting machines have been greatly improved by the introduction of automatic clamps, indicators and gauges.

Action of Different Machines.—The invention of steam rounding and backing machines increases the capacity from 500 to 1,000 books per day. The latest case-making machine feeds itself from a roll of cloth, which it automatically cuts into pieces of proper size for use. The cloth is first covered with glue by contact with a cylinder revolving in a pot of glue. It is then cut by the machine and nicked on corner sections. Boards are supplied from a holder and a back lining from a roll, both receptacles forming parts of the machine. This process completed, the newly finished product drops a little, the cloth is folded over the boards and back lining, and the binding, after passing through a case smoother, is delivered in a finished state. This automatic process is very satisfactory. There is also in quite general use a machine for covering paper books and magazines, which can, under pressure, cover 22,000 books in a day. Another device is a casting-in machine for putting the body of a book into its cover. The chief improvements now in sight in bookbinding are in the direction of casting-in, gathering, smashing, folding and sewing.

Comparative Summary of Book-binding and Blank-book Making.

	1880	1890	1900
Number of establishments...	588	805	954
Capital invested..........	$5,798,671	$10,962,034	$12,744,628
Wage-earners..............	10,612	12,473	15,971
Wages paid................	$3,927,349	$5,508,483	$6,671,666
Value of products.........	$11,976,764	$17,067,780	$20,790,858

Boot and Shoe Making.

Early Conditions.—History is somewhat scant in its references to the manner in which the people of past ages provided covering for their feet, but enough is known to reveal many of the crude devices and materials used for that purpose. Skins of various animals cut in pieces, often one piece, and adapted to the foot, were considerably used, but the luxury of foot covering was unknown to vast numbers in all ages. Much of the early population of the globe lived in climates which did not demand such protection. Besides, there was less of that locomotion with which our civilization has made us familiar. The rudimentary conceptions of life and living kept people more confined to localities. The daily goings and comings of the earlier peoples were limited, and the necessity of foot covering was not so severely felt. But with the gradual incoming and outspreading under Roman civilization, and its attendant warring necessities, the use of foot covering grew, and sandals for a long time served the needs of the people. This tendency increased with the creation of walled cities, and when the long drawn-out conflict of cities against the baronial power subsided, and modern civilization began peeping in, then more attention was given by the artisans to shoe making, who began to constitute something of a separate class, especially in those countries where climatic requirements called for protection of the feet.

First Footgear.—The earliest foot protector was a sandal, which consisted of a sole attached to the foot, usually by leather thongs. The sandal of plaited grass, palm fronds, leather or other material, continues to be the most common foot covering among Oriental races. In cold climates the primitive races shaped a rude shoe out of untanned hide, and laced it with a thong. The simplest foot covering, largely used throughout Europe, is the wooden shoe rudely cut into shoe form out of a single piece of wood. Clogs or pattens are made in England, and are wooden soles to which uppers are attached, and are largely used by agricultural and forest laborers.

Early Shoe Making.—Our present concern is with the origin and development of footgear in America. The early comers found the Indians, as a rule, fairly well supplied with a strong and substantial "moccasin" made of the skin of such animals as their arrows secured, and generally ornamented with crude beads or shells. Many early settlers availed themselves of this form of protection, and which possessed some features of hygienic advantages over the finer products of to-day.

Cradle of the Industry.—The town of Lynn, Mass., was the "cradle" of the boot and shoe industry in the colonies. The first shoemakers were Englishmen, Philip Keitland and Edmund Bridges, who came to the Massachusetts colony in 1635. They were welcomed and found a waiting market. Not only did they find a demand for their handicraft, but they found almost every colonist willing to become a shoemaker. The only difficulty was the supply of material. The Indians soon found a market for the skins they brought. These shoemakers became their own tanners, and taught their neighbors how to tan and make shoes. In 1750, John Adams Dagyr, a Welshman, had succeeded in making shoes equal to the best then made in England. Even morocco leather was produced in 1785 by Ebenezer Breed, but its development was slow.

Shoe-Making Appliances. — In 1809 David Meade Randolph obtained a patent for fastening soles and heels to the inner soles by nails, and in 1810 M. J. Brunel patented a machine for attaching soles to uppers by metallic pins. Richard Woodman patented the use of screws and staples in 1810. In 1818 Joseph Walker, of Massachusetts, invented shoe pegs. In 1851 A. C. Gallahue produced a shoe-pegging machine, and still later nailing and cable-screw machines.

It was about the year 1700 that shoes began to be made according to "sizes." The introduction of the wooden shoe peg in 1815 changed the old sewing methods. Prior to 1845 all processes of shoe making were done by hand, and the term of apprenticeship was seven years, so difficult was it to learn the various branches. The first machine appeared in 1845. The waxed thread sewing machine soon followed, and next appeared a hand-power machine for driving pegs. In 1855 a splitting machine was introduced which reduced soles to a uniform thickness; then followed peg-making and power-pegging machines and machines for cutting soles, tops and heels.

The Sole-Sewing Machine. — The invention which worked a revolutionary effect on boot and shoe making was the McKay sole-sewing machine, which was in fact the combination of several previously improved processes. This machine was adopted in 1861. An improved machine of this sort was produced by Lyman R. Blake. A second sole-sewing machine was brought out by Goodyear and McKay for welted shoes. In 1862 August Destory patented a curved-needle machine for sewing outsoles to welts, which was made commercially valuable by Charles Goodyear.

Modern Mechanical Appliances.—The modern shoe-making plant is equipped with mechanical appliances of great variety, embracing machines for cutting leather, pressing leather for sole leather, presses for cutting dies for stamping out sole and heel pieces, sewing machines of great variety, blocking or crimping appliances for molding uppers or vamps, vamp-folding machines, eyeletting machines, lasting machines, trimming and paring machines for planing and smoothing the edges of soles and heels. For finishing shoes there are scouring and sandpapering machines and burnishing machines for the soles, and stamping machines for marks and monograms, peg-cutting and nail-rasping machines for smoothing, cleaning out and dressing the surface of the insole. There is not a single operation in shoe making, however insignificant, for which machinery has not been devised.

The Artisan.—The entire shoe was formerly made by one artisan. Piece-work was the rule. In early times workmen were paid from 15 to 30 cents per pair or higher, and twelve hours was the work-day.

Expansion of the Industry.—Boot and shoe making soon extended from Lynn to adjoining towns, thence to other States, and within recent years to some large Western cities, where factories of immense proportions have been built and equipped with the latest machinery. The speed with which work is executed is almost incredible to the layman, and the diversification of employment is carried to the highest degree of perfection. Inventive talent, however, is not standing still, as the records of the Patent Office show. In 1900 Massachusetts turned out 44.9 per cent. of the total value of boot and shoe products of the United States; New York, 9.8 per cent. The great shoe centers, ranked by their value of products, are Brockton, Lynn, Haverhill, New York, Philadelphia, Cincinnati, and St. Louis follows.

While the value of products in Massachusetts increased only fractionally during the last decade, New York increased 8.1 per cent.; Pennsylvania, 27.8 per cent.; Ohio, 111.1 per cent.; Illinois, 30 per cent.; Wisconsin, 61 per cent.; Minnesota, 78 per cent.; Missouri likewise shows a large increase, all indicative of the westward trend of the industry. In 1900 Cincinnati ranked third among cities in the manufacture of women's and children's shoes. The westward drift is due to the nearness to supplies of leather and nearness to markets.

Centralization.—The development of the industry has resulted in the production of footwear characterized by its cheapness, neatness and high and enduring qualities as measured by cost. A process of centralization is in progress which decreases the number of separate establishments and increases the capacity of the smaller number. The careful taking of measurements, once such an essential requirement for the shoemaker, is now rendered practically unnecessary by the great variety in sizes as indicated by numbers and letters.

The following Table shows the Comparative Growth of the Boot and Shoe Factory Product in the United States for Three Censuses.

	1880	1890	1900
Number of establishments...	1,959	2,082	1,600
Capital invested............	$42,994,028	$95,282,311	$101,795,233
Wage-earners................	111,152	133.690	142,922
Wages paid..................	$43,001,438	$60,667,145	$59,175,883
Value of product............	$166,050,354	$220,649,358	$261,028,580

Comparative Summary of the Rubber Boot and Shoe Industry.

	1880	1890	1900
Number of establishments...	9	11	22
Capital invested............	$2,425,000	$17,790,970	$33,667,533
Wage-earners................	4,662	9,134	14,391
Wages paid..................	$1,469,038	$3,813,073	$6,426,579
Value of product............	$9,705,724	$18,632,060	$41,089,819

Bottles and Kindred Wares.

Bottles Among the Ancients.—Homer, Herodotus and Virgil all speak of "bottles" as being in common use among the Greeks, Egyptians and Romans, but they were made of leather, and they are still used in Spain, Sicily, Africa and the Far East. Earthenware bottles were used in very ancient times, and the prophet Jeremiah refers to them in his Lamentations. They were generally made with handles, and corresponded to our modern flask. Glass bottles have been found in Pompeii and in other ancient ruins.

Oldest American Industry.—The manufacture of bottles and jars is the oldest branch of the glass industry in this country. The first glass factory at Jamestown, Va., in 1608 turned out bottles. Prior to 1890 the manufacture of machine-made wide-mouthed bottles or jars was experimental. Since that date wide-mouthed jars have been made in immense quantities, one establishment in New York alone using 10,000,000 small jars for vaseline.

Inventions.—There have been nearly 3,000 patents granted on bottles and jars alone by the United States Government. Applications for improvements are being filed at about the rate of 50 a month. In recent years the consumption of cork has been so enormous that the price of good cork stoppers has become almost prohibitive for a number of uses. To overcome this obstacle, very thin disks of cork, placed in thin metal caps, crimped over a shoulder upon the neck of the bottle, have been widely introduced. Over 500 patents have been granted on devices to promote the refilling of bottles, and applications of this character are being filed at the rate of 20 per month. Substantial advance has been made in apparatus for "racking" or transferring beer to packages or casks and bottles, to equalize the pressure between the supply tank and the package.

The Mason Jar.—The manufacture of the Mason fruit jar, which was introduced in 1858, was stimulated by the introduction of machinery.

Philip Arbogast patented a process in 1882 which has been the basis for all machinery used in the manufacture of jars and wide-mouthed bottles. He employed two separate molds—a press mold and a blow mold—and by this device practically revolutionized the old method. This process was applied to the production of candy and druggists' jars, wide-mouthed bottles, jam jars, milk jars, bowls, pitchers, etc.

Beer, Soda and Mineral Bottles.—This industry represents 75 establishments. The bulk of the production is made in what is known as the "continuous" tank furnace. There is a growing demand each year for bottles for mineral waters and malt drinks, and large quantities are shipped to foreign countries.

Jar and Bottle Machines.—The numerous jar and wide-mouthed bottle machines now in use have either separate blow and press molds arranged near together on a revolving table, so that the shifting of the glass from one to the other is almost instantaneous; these molds are sometimes combined in one.

The Basic Principle.—In all methods the basic principle is the pressing of the finished neck and the subsequent blowing of the body. Compressed air for blowing and electricity for motive power have added much to the speed of the operation. Loss by breakage has been reduced to a minimum, while the finished work is far superior to that of the hand-made article.

Druggists' Ware.—The manufacture of prescription bottles, vials and druggists' ware constitutes a distinctive industry. The manufactures of homeopathic vials and prescription bottles have no superior in form and finish, and are preferred to the ware manufactured abroad. These American products are shipped to all parts of the world.

Cheap Bottle Production.—The manufacture of bottles for patent and proprietary medicines has become an important industry. Bottles of this kind are made of a cheaper grade than prescription bottles, and are used in steadily increasing quantities.

Packing Jars.—The production of bottles and jars for the packing and preserving industries has also grown to phenomenal proportions. Much of this work is done by machinery, resulting in a marked diminution in cost over older methods.

The making of bottles and jars constitutes a considerable proportion of the glass industry of the country; in 1900 the product was valued at $56,539,712. The manufacture of demijohns and carboys is receiving much attention by reason of the remarkable development of the heavy chemical industry, though the industry at present is one of minor importance.

Bottle-Filling Devices.—In one class the valve controlling outlet from the supply is controlled by the movement of the bottle to be filled so that pressure is first equalized, after which the liquid is permitted to flow by gravity, by which foaming is prevented in the packages. In another class the improvements aim to simplify the operating devices for lowering the filling head and filling tube to form an air-tight connection with the package prior to the admission of the gas under pressure and the admission of the liquid from the supply tank.

Rapid strides have been made in the improvement of partially or wholly automatic machines for manufacturing bottles in the two successive steps of pressing a blank in one mold and then blowing it into shape in a finished mold.

Comparative Summary of the Bottling Industry.

	1890	1900
Number of establishments	716	2,064
Capital invested	$5,656,705	$16,620,152
Wage earners	3,084	7,680
Wages paid	$1,511,678	$3,589,417
Value of products	$13,583,418	$41,640,672

Progress.—The extraordinary expansion in the bottling industry in the last decade, showing a threefold increase in production, is indicative of the rapidly growing habit of using bottled liquids, especially for consumptive requirements. The growth in this direction is similar to the growth in the canning and preserving industry, and marks a departure in housekeeping methods, in which so much is being done to place at the hand of the housekeeper and hotel proprietor every fluid or semi-fluid commodity which is called for by modern requirements.

Uses for Bottles. — The great demands which have arisen in recent years for fluids, preserved and condensed fruits, condiments, spices, and chemical and pharmaceutical preparations, and numerous other articles of household and general consumptive uses, have resulted in the expansion of the bottle-manufacturing industry from comparatively insignificant proportions to one of vast proportions. The facility and economy with which numerous essential articles of diet can be preserved for retail distribution has greatly broadened the market for this class of glass products.

Brass and Copper Works.

Copper History.—Copper and tin were used by the ancients to produce bronze articles, as helmets, breastplates and nails. The early mixtures of copper and tin were about 87 and 13 respectively to make bronze. Brass was made for centuries in Germany before it was introduced into England. Modeling and pattern making are both used for brass work and the materials commonly employed for modeling are pipe clay and stucco, pipe clay being decomposed feldspar, made into putty with water or glycerine. The tools used are mostly made of boxwood. The clay is modeled with the hand and wood tools. Brass is usually melted in an air crucible furnace, or where large castings are required, a reverbertory furnace is used. The fuel used is hard coke.

Early Brass Making.—Brass was supposedly first made in the United States in Waterbury, Conn., before 1749, by John Allyn. Hammered brass kettles were then made, as well as brass wire. Prior to 1835 all pins used in the United States were imported. In 1841 automatic machines were built to manufacture pins at Waterbury and Derby, Conn., where hooks and eyes were also made. The brass industry received its first impetus from the demand for metal buttons.

Bell Metal.—Bell metal is best composed of 80 parts copper and 20 tin, or 78 and 22, but there are variations from these proportions. Silver, contrary to general supposition, is not a chemical ingredient of bell metal, nor is there reason to believe that its use is desirable. Experiments have long been made to discover some other metal or alloy with copper. Cast steel and union metal, consisting of tin and iron, have both been tried.

In casting bells, it is a rule to melt the metal as rapidly as possible and to keep the surface of the metal covered with powdered coal or coke. The copper is first melted and then other metals are added. It is customary to examine samples as to grain and fracture.

Brass Founding.—Brass founding, considered as a branch of engineering, is beset with empirical rules and fancies. Guesswork is entirely too prevalent. There is a very numerous branch of alloys coming under the generic name of brass made of copper, tin, lead, zinc, antimony, and in some cases, nickel. Although brass is frequently spoken of in the Scriptures, it is a well-ascertained fact that it was copper, brass being a much later product. A well-equipped bronze works is arranged into departments: (1) Designers' room; (2) bronze foundry; (3) chasing shop; (4) model shop; (5) marble working shop; (6) enameling shop; (7) fitting and mounting shop and storeroom.

Casting in Bronze.—Old methods of casting in bronze have been discontinued. The method now pursued is for the sculptor to produce his conception in plaster. The model is embedded in sand contained in a moulding box. Piece moulding then begins. Taking a small section of the statue he forces the sand with a mallet into every fissure and crevice and thus obtains an accurate impression. Finally all the pieces are put together. The model is then lifted and turned and impressions taken from the other side. One of the advantages of this process is that if the castings peel, the artist's model remains unaltered. A new mold may be taken from it.

Where Copper is Found.—Copper is found in many parts of the world. Its use has been vastly increased in the electrical industries. It has been known since prehistoric times, and was used in ancient Assyria, all the classical nations being familiar with it. Copper mines were first opened in England in 1589 and these mines have been regularly worked since 1689. The richest copper mine in the world is at Calumet on Lake Michigan, but numerous and extensive deposits are being developed elsewhere.

Solders.—A good gold solder is made of 66.6 parts gold, 16.7 parts silver and 16.7 of copper. A silver solder is made of 19 parts fine silver, 1 part copper and 10 parts brass, or 66.6 parts silver, 30.4 parts copper and 3.4 parts brass. Brass solder is made with brass, mixed with a sixth, eighth, or even one-half brass, on 12 pounds copper and 11 pounds of zinc. A silver solder for jewelers is made of 19 dwts. silver, 1 dwt. copper and 10 dwts. brass. A solder for iron can consist of good, tough brass with borax applied, mixed with water to the consistency of cream.

Purifying Copper.—The word "copper" is derived from the Island of Cyprus, where the Greeks found it. A recently-discovered method for purifying copper is by melting 100 parts of it with 10 parts copper scales (black oxide) along with 10 parts of ground bottle glass or other flux. Copper melts at a white heat and by slow cooling may be crystallized. Its specific gravity is 9 and its melting temperature 1,996 degrees Fahr. The first reducing process of copper ore is by calcining to remove the iron. It then flows into a pit filled with water, when it becomes granulated. With further heating the slag is driven off, when it is cast in sand and is then termed "blistered" copper. It is then refined in a furnace similar to the melting furnace to free it from any oxygen it may contain. This is accomplished by adding charcoal to the copper while it is in fusion.

One Great Use of Copper.— The extraordinary expansion of electrical industries under the stimulus of demand for means for the transmission of power and intelligence has developed an enormous demand for copper. Next to gold, it is the greatest agency in modern civilization for the development of activities.

Bronze Composition.—Manufacturers of bronze composition made of zinc or cheap alloys, have a brass deposit placed on before the bronze lustre is given, as the bronzing operation is more easy and satisfactory upon brass deposits.

Ordinary potassium cyanide is often preferred to the pure article as a solution for baths. A color resembling brass is given to small articles of iron and steel by a strong stirring in a suspended tub containing 1 quart of water and of copper sulphate and tin protochloride crystallized, about one-fifth of each.

All the articles for brass plating should be suspended about equal distances from the anodes, and the anodes should be removed while the bath is not at work. Cast and wrought iron, lead and its alloys, require brass solutions richer in the metals than when deposited upon zinc or its alloys. It is also necessary to have the battery power stronger. It is somewhat difficult to keep the color of the deposit uniform.

Bronzing.—In order to obtain a steel bronze, wet the articles with a dilute solution of platinum chloride slightly heated; the articles must be free from grease and polished. The polishing powders principally employed in bronzing copper are crocus and plumbago, the plumbago giving a deeper and more permanent color. There are a number of secret processes for bronzing.

Finished Castings.—The finished castings may be brushed over with a mixture of hard, white varnish and finely-ground bronze green of an oily consistency. The castings must be slightly warmed and smooth and clean. The most simple bronze is obtained by applying on the cleansed article a thin paste made of water with equal parts of plumbago and iron peroxide, with a certain proportion of clay. This is heated, and when quite cold the article is brushed in every direction with a stiff brush.

Bronze Powders.—Bronze powders, made of impalpable brass, are applied upon metals to imitate brass, also on articles made of plaster of Paris and ceramic wares. To bronze zinc, it must receive an electro deposit of brass, and is then dipped in a weak solution of copper sulphate for a red tinge. The most beautiful cobalt plating may be obtained on brass and copper in the battery of two Bunsen cells with a moderately concentrated solution of the double chloride of ammonia and cobalt.

Copper Deposit.—Copper deposits are obtained by dipping or by galvanic methods. Iron can be coppered by dipping it into melted copper, the surface of which is protected by a melted layer of cryolite and phosphoric acid.

Galvanic Methods.—Electro-deposits of copper are made by decomposing a double salt of copper with another base, such as the double cyanide of potassium and copper.

Cold Baths.—The cold baths are put into well-joined tanks of oak or fir wood, lined inside with gutta-percha. The vertical sides are also covered with sheets of copper, which act as the solution anode and reach to just below the top edge of the tank.

Hot Baths.—The hot baths are put into stoneware vessels heated in a water or steambath, or into an enameled cast-iron kettle placed directly over the fire. The insides are also lined with an anode of copper, connected with the positive pole of the battery, and the edges of the vessel are varnished or support a wooden ring upon which rests a brass circle communicating with the negative pole, from which circle the articles to be electroplated, hang.

Coppering Silverware.—Large pieces of silverware may be coppered in these baths. Small articles are threaded upon a zinc or iron wire or are placed in a perforated ladle.

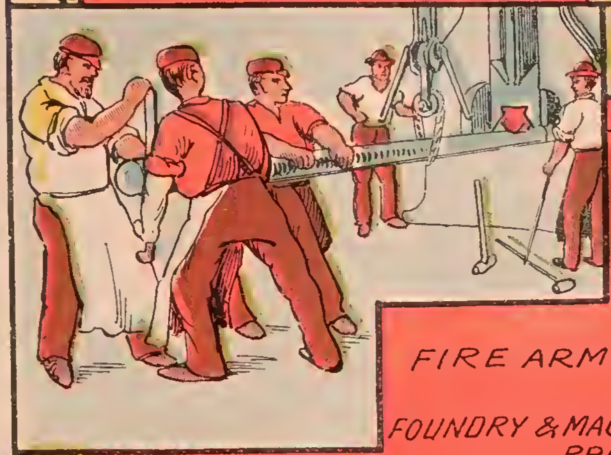
Gilding.—There are three methods for applying a coating of gold, by amalgamation, dipping and cementing. Mercury gilding furnishes gold with a bright, dead lustre. Gilding can be done without a battery by using a salt or acid liquor, into which the articles are plunged attached by zinc wires into gold baths.

Statistics. — Brass was made in the United States to the value of $2,549,860 in 1890, and $1,419,817 in 1900; brass and copper rolled $8,381,472 in 1890, and $37,536,325 in 1900; brass castings and finishings, $24,344,434 in 1890, and $30,343,044 in 1900; brassware, $13,615,172 in 1890, and $17,140,075 in 1900. Copper smelting and refining involved a capital of $53,063,395 in 1900, with an output valued at $165,131,670.

BRASS AND COPPER INDUSTRY

	NO. OF ESTABLISHMTS	WAGE EARNERS	WAGES PAID DOLLARS	VALUE OF PRODUCT DOLLARS
BRASS	10	162	98,796	1,419,817.
BRASS & COPPER ROLLED	19	6,759	3,512,781	37,536,325
BRASS CASTINGS	442	11,964	6,070,762	30,343,044
BRASS WARE	204	7,668	3,550,074	17,140,075
BRONZES	21	621	372,797	2,229,329
COPPER SMELTING & REFINING	47	11,324	8,529,021	165,131,670
SCALES & BALANCES.	86	2,775	1,436,839	5,239,788

IRON & STEEL INDUSTRIES.



	NO. OF ESTABLSHMT	WAGE EARNERS	WAGES PAID DOLLARS	VALUE OF PRODUCT. DOLLARS
BRIDGES	196	12,181	6,711,260	30,151,624
CUTLERY & EDGE TOOLS	309	12,069	5,673,619	14,881,478
FILES	86	3,160	1,277,199	3,403,906
FIRE ARMS	32	4,482	2,542,366	5,444,659
FOUNDRY & MACHINE SHOP PRODUCTS	9,324	350,327	182,232,009	644,990,999
FOUNDRY SUPPLIES	30	278	135,887	1,128,856
GAS MACHINES & METERS	114	2,167	1,185,959	4,392,730
HARDWARE	381	26,463	11,422,758	35,846,656
SADDLERY HARDWARE	80	2,940	1,217,202	4,149,489
HORSESHOES (FACTORY PRODUCT)	6	167	90,527	387,619
IRON & STEEL	668	222,490	120,820,276	803,968,273
IRON & STEEL (BOLTS, NUTS, ETC.,)	72	7,660	2,991,857	13,978,382
IRON & STEEL DOORS & SHUTTERS	13	117	85,683	319,629
IRON & STEEL FORGINGS.	91	4,688	2,559,433	10,439,742
NAILS & SPIKES	102	4,477	2,042,250	14,777,299
IRON & STEEL PIPE, WROUGHT.	19	5,536	2,495,898	21,292,043
IRON WORK, ORNAMENTAL.	672	20,646	11,111,226	53,508,179
SAWS	96	3,215	1,692,757	6,443,748
SCREWS	33	3,527	1,423,838	4,658,467
WIRE	29	1,603	859,645	9,421,238
WIRE ROPE & CABLE	597	9255	3,934,525.	19,942,882.
SPRINGS.	48	2,102	1,061,006	5,690,499.

Brass Industry, The.

Branches of the Industry.—Brass, the most valuable and probably the most universally used alloy in the mechanical arts, as well as the longest and best known is an alloy of copper and zinc, with occasionally one or two other ingredients. It has divided itself into various branches, as brass casting, cabinet, bell and brass-foundry work, plumbers' brass work, stamped brass, rolled brass wire and sheathing, tube making, lamp making, gas fitting and naval work, and one or two others, though several of these branches are frequently conducted in the same establishment.

Diversified Uses.—The utilization of brass in the industries extends into almost every branch and it serves most important purposes. The processes of manufacture into the numerous forms into which it is converted have led to the construction of intricate and powerful mechanical appliances which reflect extraordinary inventive skill as well as mechanical genius. The processes for stamping brass work and of rolling it have been brought to a high state of perfection, and in wire drawing especially inventive talent has accomplished grand results which are controlled by patents. Tube making has also been revolutionized and radically new processes have supplanted all older methods in the production of tubing at a speed and with an economy which would surpass the belief of those unfamiliar with the details of its manufacture, and which are beyond the province of a brief reference.

Union of the Two Elements.—The industry since the invasion of machinery, in almost every portion of which it is present, has assumed phenomenal proportions. Copper alone would be useless, being too soft; zinc alone would be useless, being too brittle. The two in uniting constitute a powerful alloy interpenetrating the microscopic recesses and filling them up and clinging together with an affinity and mechanical cohesiveness which transforms the separate nature of each metal into a new metal. The accompanying figures reveal the scope and extent of the mighty industry.

The various processes of brass working are casting, rolling and drawing, stamping, tube-drawing and casing and brass finishing. Castings are made into common-cored and pulse-cored castings. Sheet brass is the raw material of stamped work, and is stamped into a vast number of useful articles, among them cornices, pole ornaments, curtain rings, door and shutter knobs, lamp burners, culinary articles and articles for use in chemical and manufacturing plants.

Wire Drawing.—Much material is consumed by being drawn into wire. Strands are cut out square in section, and are drawn through a succession of circular holes in a steel draw-plate till the desired fineness is reached, being repeatedly annealed in the process. The uses of brass wire are almost innumerable.

Tube Making.—The present processes of tube making have revolutionized all former methods, and are patented. The method ignores all past experience, and exhibits one of those remarkable triumphs of mechanical genius by which prepared material is by a simple and direct process converted into tubing at a marked economy over all older methods, thus producing the seamless brass tubes of the present day.

Brass Finishing.—Finishing consists of dipping, burnishing, lacquering and sometimes bronzing, in which nitric acid, polished steel tools, coating with a specific varnish over heat and an opaque pigment are successively used.

The use of brass in machine construction and for machine ornamentation is quite extensive, and fills a place which cannot be filled with any other known metal.

Comparative Summary of the Rolled Brass and Copper Industry.

	1880	1890	1900
Number of establishments...	26	16	19
Capital invested............	$9,057,000	$8,041.593	$15,629,766
Wage-workers..	5,082	2,698	6,759
Wages paid..................	$2,524,169	$1,380,328	$3,512,781
Value of products...........	$14,329,731	$8,381,172	$37,536,325

The industry of brass castings and furnishings is still greater, the figures being as follows:

	1880	1890	1900
Number of establishments...	396	453	442
Capital invested............	$5,740,237	$18,663,286	$21,925,039
Wage-workers	6,237	10,943	11,964
Wages paid..................	$2,729,794	$5,758,333	$6,070,762
Value of products...........	$10,808,742	$24,344,434	$30,343,044

In addition to these branches is that of making brassware, the extent of which is as follows:

	1880	1890	1900
Number of Establishments...	20	113	204
Capital invested............	$594,582	$10,866,001	$12,194,715
Wage-workers	1,142	7,157	7,668
Wages paid..................	$411,329	$3 557,069	$3,550,074
Value of products...........	$1,513,098	$13,615,172	$17,615,172

Brick Making and Bricklaying.

Early Brick.—Brick has been used from the earliest times as material for construction. The remnants of past civilization indicate that the art of brick making was well understood, though the workmanship was crude and without that system of production which has been attained in modern times. It is used more extensively in construction than any other material excepting wood, and is practically indestructible as against weather, acids, atmosphere or fire. Brick is manufactured in any desirable shape, size or color.

Three Methods.—Three methods of manufacture are followed, namely—the use of soft mud, stiff mud and dry clay. Within recent years the application of machinery to brick making has reached a high point of development, and the old hand-methods are being gradually rendered less profitable. Soft-mud brick is made under little or no pressure, and is generally of better shape than stiff-mud brick, the latter often showing laminations. Soft brick requires longer time to dry, but is more easily made.

Three Styles of Kilns.—Three styles of kilns are used, namely—up-draft, down-draft and continuous; the first style is less frequently used. A down-draft kiln requires permanent walls and a tight roof, wherein the heat practically enters at the top; in continuous kilns, two parallel brick tunnels are connected at the ends, the outer walls being generally 8 feet thick at the bottom and 4 feet at the top, in which numerous flues are built. These kilns are divided into numerous sections, which are successively used. Less fuel is required per unit of output, and a larger percentage of No. 1 brick is turned out in this style of kiln.

Enameled Brick.—Enameled brick is made from clay containing a considerable portion of fire-clay. It is more durable than glazed brick, because it is homogeneous throughout. Glazed brick is advantageously used for a variety of purposes, such as public eating-rooms, corridors, markets, stores, etc.

Paving Brick.—Paving brick is usually made of shale, which often contains as much as 30 per cent fire-clay, the difference between it and common brick being in the burning. Building brick is classified as common, arch or hard brick, red or well-burned brick, salmon or soft brick, stone brick, pressed or face brick, molded, arch and circle brick.

Brick Colors. — The color of common brick largely depends on the composition of the clay used. Pressed brick is made of the same material, but is colored artificially by a mixing of clays or mineral paints or mortar colors with the clay in the dry pan. Brick are sometimes colored by mineral pigment.

Sizes.—In New England, common brick averages $7\frac{3}{4} \times 3\frac{3}{4} \times 2\frac{1}{2}$ inches. In most Western States the customary size is $8\frac{1}{2} \times 4\frac{1}{2} \times 2\frac{1}{2}$, but sizes vary occasionally in burning, hard brick being from one-eighth to three-sixteenths of an inch smaller than salmon brick. Pressed brick is more uniform in size, the prevailing size being $8\frac{3}{4} \times 4\frac{1}{8} \times 2\frac{3}{8}$. The National Brickmakers' Association and the National Traders' and Builders' Association have adopted $8\frac{1}{4} \times 4\frac{1}{8} \times 2\frac{1}{4}$ as the standard size for common brick, and $8\frac{3}{8} \times 4\frac{1}{8} \times 2\frac{1}{4}$ for face brick. Common brick average $4\frac{1}{2}$ pounds each, and pressed brick from 5 to $5\frac{1}{2}$ pounds each. A good brick does not break under a center load of less than 1,620 pounds, the brick lying flatwise and having a bearing at each end of 1 inch and a clear space of 6 inches. A first-class brick should carry 2,250 pounds in the center without breaking. Brick has been tested which carried 9,700 pounds before breaking.

Grouting.—Grouting consists in laying inside brick on a bed of mortar, and filling all the joints full of very thin mortar. If well done, it makes strong work. "Bonding" is the arranging of brick so that the weight of the brick above rests on both sides of the bond. A brick laid with its side parallel to the face of the wall is called a "stretcher," and when laid at right angles, so that its end is parallel to the face of the wall, it is called a "header." The English bond consists of alternate heading and stretching courses. The Flemish bond consists of alternate headers and stretchers in every course, every header being immediately over the center of a stretcher in the course below. Pieces of hoop iron are often laid flat in the bed joints of brickwork to increase longitudinal tenacity and prevent cracks. The corbeling of the wall prevents the weakening of the wall by the ends of the floor timbers.

Bonding.—The best method of bonding hollow walls is by means of metal ties provided with a drip in the center. The American custom is to prevent air spaces. "Nogging" is a term applied to brickwork filled in between the studding of wooden partitions to obstruct the passage of fire, sound and vermin. A preparation known as "duresco" is sometimes used by builders to prevent efflorescence, which is a cause of much trouble, and for which there appears to be no absolute remedy.

Measuring Work. — Brickwork is generally measured by the thousand brick in the wall. The usual custom is to take the outside superficial area of the wall, and multiply by 15 for an 8 or 9-inch wall, or by 22½ for a 12 or 13-inch wall, and by 30 for a 16 or 18-inch wall, the result showing the number of bricks. In the Western States, where bricks are larger, this calculation gives about one-third more than the actual number of brick in the wall, and the price is correspondingly regulated. (See MECHANICAL ARITHMETIC, in this volume.)

Kinds of Brick.—Brick are variously designated from common to pressed, and vitrified brick used on the upper course of a wall are termed capping brick. Clinkers are named from their glass-like sound. A coping brick is a kind used for a coping course. A feather-edge brick is one that is used for vaults, arches and niches. Fire-brick is used as furnace linings and kilns, and are burned extremely hard. Hollow brick have openings for ventilation. Stocks is the term applied to the best make of brick in some localities. Burr brick are those vitrified by excessive heat.

New Brick-Making Methods.—The operation of brick making has been radically changed since the introduction of machinery, by which enormous quantities are produced, of uniform composition, exact shape and known quality. The processes may be generally classified as preparing the earth, tempering, molding, drying and burning. Quality is determined by freedom from cracks and flaws, hardness, and regularity of shape and size. Fire-brick is valuable because of the absence of lime, magnesia, potash and metallic oxides, which act as fluxes. The outer walls of many modern houses are generally of brick or brick-and-a-half thickness.

New Brick Composition.—A recent brick composition is made of 91½ parts clay, 3 parts iron filings, 2 parts table salt, 1½ potash, 2 elder or wood ashes, heated to a temperature of 3,362 degrees Fahr. for five hours, run into molds, then baked at from 842 to 932 degrees Fahr., then colored with various mixtures to suit.

Modern Brickyards.—The modern brickyards are models of mechanical efficiency in the rapid handling of large quantities of clay in its various steps to the finished product. Appliances for the generation and conduction of heat evenly and in sufficient volume have been wonderfully improved during the past decade, by which the cost has been reduced and the quality of work safely guaranteed. The increasing use of fire-brick in many industries has resulted in the production of brick of fire-resisting qualities on a large scale. The brick industry is most prosperous, and, as the statistics show, is rapidly growing.

A Comparative Summary of the Brick and Tile Industry in the United States is as follows.

	1880	1890	1900
Number of establishments..	5,631	5,828	5,423
Capital invested	$27,673,616	$82,578,566	$82,086,438
Wage-earners	66,355	104,176	61,979
Wages paid..................	$13,443,532	$29,709,357	$21,883,833
Value of products...........	$32,833,587	$67,770,695	$51,270,476

Bridges and Bridge Construction.

Influence of Railroads. — The introduction of railways wrought a revolution in bridge construction. The early bridges, formed mainly of timbers and rudely constructed, furnished means for travel across streams and over inequalities in the surface of the ground. With the advent of the railway and the introduction of cheap iron and steel, engineers at once adopted iron and steel as the best and readiest means for the quick construction of durable bridges at a comparatively small cost. The science of bridge construction itself has been highly developed within the past twenty-five or thirty years; in fact, all the old-time theories as to construction have been thrown overboard and new theories of construction as well as systems of construction, based upon tests and experiments as to strength of material, have supplanted lumber and timber for that purpose. Bridge building is now a recognized science and forms one of the most important branches of study in schools and colleges.

Cheap Steel.—It was the cheap production of steel, due to improved steel-making process, that led to the universal adoption of steel for bridge-building purposes. The cheapening metallurgical processes established in the conversion of ore into crude iron and crude steel, and from thence into finished steel, have opened a wide field to the engineer and have resulted in the development of engineering science to one of the first sciences in the world. Methods of bridge construction have also been greatly improved and the material for bridges is now made in the structural mill according to specifications, ready to be put into place.

Construction now consists simply in assembling the parts so formed and securing them in place by means of bolts, nuts and other tying appliances by which a practically continuous roadbed of steel is secured, free from serious vibration and capable of sustaining immense traffic for years.

One of the features of modern bridge construction is the eye bar, the preferential use of which is giving occasion for much technical discussion among engineers. The specific parts of structural material is known as angles, tees, beams, channels, zee bars and plates.

American Bridge Work the Best.—Much interesting and scientific literature has appeared during the past twenty years in reference to bridge construction and it manifests a degree of scientific achievement which is highly creditable to American skill. American bridge material is preferred throughout the world, not merely because of the enduring and reliable quality of the steel used, but also because of the despatch with which construction is effected. Constructing engineers have developed their craft to a high degree of perfection and have surprised the engineers of Europe by the speed with which they span chasms and rivers with their splendid specimens of engineering, designing and skill.

Comparative Summary of the Bridge Building Industry.

	1880	1890	1900
Number of establishments...	75	137	196
Capital invested..............	$4,058,649	$10,960,218	$16,768,948
Wage-earners................	4,293	8,382	12,181
Wages paid.............. ...	$1,882,179	$4,951,133	$6,711,260
Value of products...........	$8,978,122	$21,868,068	$30,151,624

Bronze and Bronzing.

Art of Bronzing.—Bronze is an alloy of copper and tin, to which small proportions of other metals, especially zinc, are added, and is used for statues, bells, cannon, etc. Phosphor-bronze is made by adding phosphorus. Bronzing is the art of covering metal, wood, clay, plaster, etc., by means of bronze powders. Bronze powders made of very finely cut brass are applied on metals, also upon plaster of Paris and ceramic ware. A steel bronze is obtained by wetting the articles with a dilute solution of platinum chloride and slightly heating. The art is complex, there being so many methods to pursue and materials to use in proper proportions. The most simple bronze is made of a paste of equal parts of plumbago, iron peroxide and water, and a suitable proportion of clay. This process gives a very bright red bronze. The common bronzing solutions for metallic statuettes are made of potassium binoxulate and sal-ammoniac in strong vinegar.

Actual Secrets Preserved.—The real secrets of bronzing are confined to the few who follow the business. The domains of chemistry and metallurgy are invaded to obtain material and methods. It is impossible to give instructions except for the simpler processes which do not require expert skill. Bronzing is done on brass, copper, copper utensils, electrotypes, gas fittings, iron, medals, paper, plaster, tin, wood and zinc. There are various methods of bronzing, known as ancient, Chinese, Egyptian and phosphor bronzing. There are various bronzing compositions for coloring bronze as well as pickling solutions.

Bronze molds are made of various compositions, according to the objects for which they are constructed. Plaster is the most common, but wax and gelatine are also much used by artists. When casting in bronze, the material used must resist the intense heat of the liquid metal. The waste wax process enables the sculptor to produce original bronzes in his own studio. Casting involves five processes, viz.: the construction of the hollow mold, preparation of fluid material, pouring, solidification, and lastly, liberation of the cast from the mold. Bronze fundamentally is a metallic oxide of copper, and varies from black to red, the two extremes of copper oxide. Various rules are in use for making bronzing powders. The art can be readily acquired by following the prescribed directions and rules, and artistic work can be produced by ordinary care at small cost.

Comparative Summary of the Bronze Casting Industry.

	1880	1890	1900
Number of establishments...	7	14	21
Capital invested..............	$186,500	$710,190	$881,769
Wage-earners................	153	271	621
Wages paid...................	$64,072	$195,535	$372,797
Value of products...........	$670,912	$1,165,163	$2,229,329

Building Materials and Construction Work.

Materials Used in Construction.—Building materials may be roughly enumerated under iron, steel, lumber, in various forms, cement, plaster, brick, stone, slate tile, and various fireproofing materials necessary for protection from fire. There is a variety of other materials used in modern building requirements which have within twenty-five years built up a number of minor industries. The general use of iron and steel in large building construction has very greatly increased because of the rapidity with which construction can be prosecuted, the quickness of obtaining material and the relatively low price for it considering the durability.

Advantages of Iron and Steel.—The use of iron and steel in construction reduces danger from fire and consequently lessens cost of insurance and admits of the construction of much higher buildings than would be possible with the use of lumber. The material also occupies less space and permits the construction of partitions of lighter material.

Skeleton Construction.—Over 914 patents have been issued for the construction of iron buildings, most of them based upon the steel skeleton and tile casing idea. Various patents have been granted which show a marked advance in interior wall and ceiling construction in which embossed sheet metal forms a prominent finishing feature. One valuable improvement is the metal facing of exterior walls for buildings.

Caisson Work.—Caisson work as applied in setting foundations for modern tall buildings has been recently considerably improved. The evolution of the tall building has induced extensive study of means and methods for obtaining the maximum of strength and stability with the minimum of weight and space occupied.

The Engineer.—The experience had in the construction of abutments and piers has been successfully applied to the sinking of foundations to datum for many of the larger office buildings. Engineering talent has scored remarkable triumphs in some recent foundation work where unusual difficulties were presented, and in simplifying and elaborating methods of construction in every department of building. Old rules and methods are disappearing under the light of investigation, research and experience, and engineering processes involving entirely different conceptions are being applied to the solution of difficulties which a generation ago would not have been attempted.

Tile and Metal System.—Various improvements have been made in construction in the use of concrete and metal. The tile and metal principle is being applied in the construction of large fireproof grain elevators, which is a remarkable step of progress.

Lumber in Construction.—The use of lumber as a building material, while proportionately declining in large structures, is increasing in consumption throughout the general building trades. The general tendency, however, is toward minimizing of lumber in construction and the increasing substitution of other more durable materials, such as iron, steel and concrete. The development of the saw-mill industry and the planing-mill industry, where much material is cut to specific dimensions for immediate use, contributes to the facility with which work can be done. House and all manner of construction has been greatly simplified and systematized by the specific preparation of lumber for construction in floors, partitions, stairways, sash, doors, etc.; in fact, the decentralization of the lumber industry has revolutionized building construction.

Concrete in Construction.—The use of concrete as a building material has recently grown to enormous proportions, and is destined to be very greatly increased by reason of the economy realized, the lasting quality of the material and the freedom from conflagration. The use of concrete was first introduced on a large scale by railway companies, which built foundations for various purposes with it, as well as using concrete in foundations and arches in bridge building. Entire buildings are now being built of concrete, some prominent illustrations of its value being seen in paper-mill construction and in plants for mechanical and engineering work. It is finding its way into smaller building operations, and is increasingly used in basements and walls in common with cement.

Glass in Construction.—Glass as a building material is also rising in importance, and a number of kinds have now an established sale. The processes of manufacture are mostly of recent origin, and represent a high degree of inventive ability and mechanical skill and ingenuity.

Glass for Skylights.—The use of glass for skylights, partitions, and in iron and wooden frames for exterior walls, is growing; it permits abundance of light in interiors, and where specially framed in sash frames that can be swung on hinges, affords ventilation. Special glass material is also produced for flooring, which presents some preferable features over wood floors in office buildings and public buildings.

Comparative Advantages.—Lumber may be regarded as the basic building material in more or less primitive conditions of society; brick, which may be regarded as slightly mineralized earth, will probably always remain an important constituent in building material. Stone, which is a geological formation, can never cease to be an important factor in construction; iron and steel, which are metallurgical products of a geological formation, are an assured reliance in construction as long as the ore lasts. The value of steel in construction consists in its great strength, its comparative immunity from destruction by fire, especially when encased in concrete, and its utility in affording a maximum of enclosed space in buildings with a minimum of material. Glass as building material presents some possibilities of more extended use in floors, walls and ceilings, but the cheapening of cement will probably restrict its opportunities in that direction. Cement and concrete, which are largely a product of semi-geological formation, are to-day perhaps the most promising materials in extensive building operations, and may, in the not remote future, constitute the chief dependence of builders, especially when architects lend to it their approval and form it into pleasing and artistic shapes, and sculptors condescend to lend their aid to form it into pleasing molds and figures in various hues and colors.

Architecture has played its rôle in Europe. Its new life is to be lived in America, and the designers and seekers after a better building material than lumber, iron, steel, stone or glass, will probably ere long evolve a material which will revolutionize construction and impart vitality to architecture that will transform the abodes of man into radically different abiding places.

Brick in Construction.—The place of brick in the list of building materials can never be filled by any possible substitute, but its use, as in the case of lumber, is relatively declining, though, as measured by volume of production, rapidly increasing. The abundance and accessibility of unlimited supplies of clay encourage the use of brick, coupled, as its manufacture is, with remarkable labor-saving appliances, which produce brick with great rapidity and of specific qualities.

Stone in Construction.—The older civilization of Europe found in stone its chief supply, but with the volcanic-like upheaval of Europeans into America, particularly within the last one hundred years, lumber became of necessity the main reliance. Every tree was a small locked-up lumber yard, awaiting only the axe, saw and plane to transform it into material ready for use in construction. The sudden outburst of human necessities, especially in America, led to its almost universal use, but with more settled conditions, brick, and later stone, have come into use. With the individualization of wealth came the demand for the more permanent and elegant structures, from the family home to the public building, which stone only could meet.

Slate in Construction.—Slate is growing in use slowly, but as much roofing is now of flat construction, there is less opportunity for this material as measured by the availability of other and preferable materials.

Tile in Construction.—Tile is more important in its ornamental than in its utilitarian aspects, and yet the figures of production indicate its rapidly increasing use in very much building construction. It serves several purposes and is in much request by builders and in high favor among architects within certain well-defined limits.

Demand for New Material.—There is an unanswered demand for some new building material, which concrete comes nearest to answering. Lumber supply is regarded as uncertain, though with the development of more comprehensive means of transportation by land and water, it is probable the world will find an abundant and never-failing lumber supply in more remote quarters of the globe which are as yet strangers to the woodman's axe.

Cement. — The first improvement over wooden bridges was steel. The wealthier railroad corporations have followed steel with concrete and cement in a few instances. Civil engineers have latterly turned with favor to cement for bridges, and this material for short spans will probably be freely used. The method of construction is somewhat as follows: A wooden substructure is first built. Upon this the floor of the bridge is laid. Upon 4 inches of cement, $1\frac{3}{4}$-inch steel rods are laid, running lengthwise and 10 inches apart. Three inches more of cement are laid on this, then a layer of woven wire is put on. Over this another coating of cement is laid, then another layer of wire, and on top of all enough cement to make up the total thickness of 14 inches. The railing, which is also strengthened with wire, is an important factor, as it helps to bind the bridge together and increase its strength. This is by reason of heavy bolts run downward through the railing and fastened firmly to the floor.

A New Material Wanted.—The use of cement and concrete promises some revolutionizing methods which may even attack the supremacy of iron and steel. Schemes and plans for mechanically casting entire buildings by forcing concrete into molds, are being considered by progressive engineers and builders.

New Materials Coming In.—This system is a marked improvement in large structures, and is meeting with wide approval among engineers, architects and builders. Tile and concrete are rapidly finding wider use for their economic and architectural features. The use of metal-wired concrete is also extending as a valuable material for partitions in tall buildings, where every consideration demands that the least possible space be taken up by partitions. Metal-wired concrete furnishes light, thin, strong and theoretically fireproof partitions. There are various kinds of this material on the market, all protected by patents.

How Building Material is Sold.—Lumber is usually sold by the thousand feet, on a basis of one inch thickness of board, and is furnished by sawmills in any desired length, width and thickness at a given price per thousand feet, or, as designated, per M.

Steel.—Steel is usually sold, when furnished for construction, by the ton or pound, and the engineer furnishes "specifications" as to the number of pieces, with the length, breadth, thickness, flanges, etc., and sometimes the weight desired, weight per running foot of material, together with the physical constituents of the steel as to modulus of elasticity, breaking and bending strength, and compressibility; also, there are frequent chemical requirements specified as to the elementary constituents of steel, especially with reference to contained carbon, phosphorus, etc., all of which enter into estimates and calculations in the determination of the requirements of the material with reference to the strains to be endured and loads carried and resistance to shock and winds and other possible influences.

Stone.—Stone, when quarried, is usually sold by the perch, although this old-fashioned rule has reference to common building stone, and not always to granite, marble, etc. Special rules prevail for some quarry products, because of the character of the quarrying, the size and shape of the blocks to be produced, and other considerations of a commercial nature.

Glass.—Glass ordinarily is sold by the box of 50 or 100 square feet, but this method has reference to cheap window and some other kinds of glass. In case of glass used in building construction, entirely different rules prevail, weight being the chief consideration. Most of such glass is made for specific purposes, and is the subject of special bargaining.

Cement.—Cement ordinarily is sold by the barrel of established size and contents. Concrete follows, in small dealings, practically the same rule, but in large dealings specifications frequently deal with quantities in bulk, which are measured by the ton, though shipped and delivered in small packages.

Brick.—Bricks usually are sold by the thousand, but here again the old established rule is not uniformly followed. Prices are determined by quality of clay, length and manner of burning, size and shape and manner of finish, as well as composition

Slate.—Slate is usually sold by squares, which has been found to be an easy and practicable method for almost all kinds of material used. Tile is sold in some places by weight or according to length, thickness, diameter, shape or amount of work represented in particular lots.

Recent developments in the manufacture of building material have introduced modifications in the manner of selling, as well as in what shall constitute the unit of value. This is due to the great diversity of products and to differing qualities of each and the different degrees of labor, skill and care involved in their preparation for specific uses and requirements.

Comparative Summary of Brick and Stone in Masonry.

	1880	1890	1900
Number of establishments..	1,591	7,715	8,333
Capital invested...........	$3,990,706	$54,969,408	$48,070,239
Wage-earners...............	16,020	110,618	93,568
Wages paid.	$6,800,866	$69,311,083	$53,152,258
Value of products..........	$20,586,553	$204,165,642	$203,593,634

Button Making.

Earliest Modern Buttons.—The earliest appearance of the button for modern application was found during the time of Edward II. Buttons then were wholly produced by needlework with the exception of the wooden mold. Buttons are divided into three classes, known as shank buttons, hole buttons and covered buttons. A great many buttons were first made with a wooden mold and covered.

Metallic Buttons.—Buttons of glass are found on dresses of the sixteenth century; metallic buttons, manufactured in England, appeared about 1670, and in 1687 and subsequently, their manufacture was conducted on an extensive scale at Birmingham. Gilt buttons were first made in 1778, and of papier-mache in 1770.

Improved Methods.—In 1807 a button was made consisting of two disks or molds made of sheet-glass or tin, the upper disk having its edge turned up, and which was covered with cloth. The under disk, which was smaller than the upper and convex in shape, had a wire shank put inside. The material to keep the shank in place was inserted, and the two disks were pressed together, the turned edges interlocking, making a perfect button; though many improvements have been made in button making since then, this principle has never been superseded.

Buttons in the United States.—Casper Wistar first manufactured brass buttons in Philadelphia about 1750; he was soon followed by others, who manufactured buttons of apple, holly and laurel woods; in 1797 there were two large button shops in Philadelphia which did a fair business. The soldiers of the Revolution wore metal buttons which were imported from France. Ivory and horn buttons were made in Waterbury, Conn., in 1812. Quite a number of early attempts were made to establish the industry on a large scale, but there were many failures because of the mechanical difficulties encountered. The business did not take definite shape until after proper materials for button making were supplied.

First Button Factory.—The first regularly established button factory which might be called a factory was established at Waterbury, Conn., about 1800. Buttons were there made of block tin or pewter in cast-iron molds. No substantial progress was made, however, until 1820, when James Croft, an Englishman who had a thorough knowledge of the business, established a successful factory in Connecticut. The industry took on life at Easthampton, Mass., in 1827.

Material Used.—About 1875 certain fossil and vegetable gums were discovered which combined with fine carbonate of lime, feldspar, mica or kindred minerals and mixed in steam-heated grinders, made the proper plastic material for button manufacture. Buttons are now made of celluloid and potatoes which cannot be distinguished from horn. The industry of manufacturing fresh-water pearl buttons has its center at Muscatine, Iowa. During the census year 5,432,216 fresh-water pearl button blanks were manufactured, valued at $656,036; ocean-pearl buttons constituted 30.2 per cent. of the total value; fresh-water pearl buttons, 18.2 per cent.; metal buttons, 13.7 per cent.; ivory, 17.7 per cent.; brass, 11.4 per cent.; cloth covered, 7.2 per cent.; wood buttons, 1 per cent. of the total value. Factories engaged in their production line the Mississippi river from Red Wing, Minn., to Louisiana, Mo. Buttons are also made from seaweed, skin, milk, blood and other material.

Improvements of Machinery.—Improvements in button-making machinery have been so rapid that frequently manufacturers have been obliged to tear out, every few years, their old machinery to make room for new. The Western factories cut the buttons in blanks and send them to Eastern factories to be stamped out. The polishing is effected by placing the buttons in bulk in large wooden tumblers, or keys, where they are subjected to the action of chemical fluids by revolution. One feature of the industry is the production of buttons more for ornamentation than actual use, as, for instance, on ladies' apparel and for naval and army purposes and for State militia use and various other uses. These buttons are of various materials susceptible of high polish, and are exceptionally well made. For this purpose specially devised machinery is used in some factories.

Comparative Statement of the Button Industry.

	1880	1890	1900
Number of establishments...	124	106	238
Capital invested............	$2,013,350	$3,089 265	$4,212,568
Wage-workers..............	5,825	3,831	8,685
Wages paid.................	$1,645,130	$1,411.089	$2,826,238
Value of products..........	$4,449,542	$4,216,795	$7,695,910

Canning and Preserving Industry.

Preservation of Foods.—The industry of preservation of foods is of comparatively recent origin. Prior to 1795 salt and sugar were the chief agents used. The offer of the French government in that year of a reward for a method of preserving food for sea service brought to the fore a method by Nicholas Appert, which proposed hermetic sealing. The government purchased the process, gave it to the public and the industry thereupon spread. In 1810 Peter Durant patented in England a newer process for the preservation of fruits, vegetables and fish in hermetically sealed tin and glass cans.

Canning in the United States.—The industry spread to the United States, and a number of products were canned, among them salmon, lobsters, oysters; pickles, sauces, jellies, jams, mustard, quinces, cranberries and currants received special preparation.

Inventions.—In 1825 Thomas Kinsett, of New York, patented a tin can made with a plumb joint, and in 1847 Allen Taylor invented the stamp can tops. The latest device is the key-opening can.

In 1874 A. K. Shriver, of Baltimore, invented a closed process kettle to cook by superheating water and steam, to which process dry steam was soon after applied and which latter method is now in use.

Basis of Preservation.—Preservation is based on the fact that the decomposition of food is due to the presence of a living organism known as ferment. It was reasoned that everything that would preclude its presence or kill its organism would preserve the article treated. Fruits and vegetables were the first successfully canned goods. The method used was to fill glass bottles to the neck with fruits, then loosely cork the bottles and place in tepid water. The temperature was gradually raised from 170 degrees to 190 degrees and the bottles were kept in it from 30 to 60 minutes, then sealed and cooled. This method was long ago improved upon by placing the fruit in a tin can containing water; a lid with an aperture was placed on it and heat was applied. After a little boiling the aperture was closed with a drop of solder.

Canning of Fruits and Vegetables.—The canning of fruits and vegetables has increased of late with greater rapidity than any other branch of the canning industry. The industry is widely diversified, but immense centers have been built up at various points. The best of fruits, vegetables, and meat products are now canned and are recognized as deserving of place in the larders and pantries of the most luxurious household and hotels at home and abroad. Domestic responsibilities have been very greatly curtailed by the enterprise and skill of canners who are even more energetically than ever prosecuting their efforts to bring within reach of the consumer every good and wholesome article of diet.

Care in Packing.—The industry has assumed extraordinary dimensions because of the conscientious care which is taken to preserve all the constituents of the products canned. The goods are purchased in immense quantities in the appropriate seasons at lowest possible prices and are transported to convenient factories, where under the action of mechanical processes and appliances of the highest economical value they are canned by most cleanly and scientific methods and made attractively available for table use. In the canning of different varieties of fruits, California ranks first, producing 53.7 per cent. of the total product.

During the past fifteen years labor-saving machinery has been introduced in can manufacture, until now all the parts are put together by mechanical devices. Tin cans are made from Bessemer steel plates cut into sheets 14x20 inches, weighing one pound, and coated in tin.

The introduction of the patent-process kettle, about 1883, led to a general expansion of the industry until now canneries are found in all fruit and vegetable-raising localities.

The production of jams, jellies, condiments, catsup, apple butter and soups is a most important branch of this industry. Many establishments add the preservation of pickles, preserves and sauces.

Canning methods are improving every year through the use of machinery. The improvements have been made mainly in lessening the period of cooking, permitting the escape of heated air in the cans, and in the case of fish, in softening the small bones, and in the filling, capping and labeling and boxing of the cans.

Salmon Packing.—In the salmon canneries the salmon are first weighed, then washed in an ice-cold bath; the heads, fins and tails are severed, the viscera are then removed; the fish are again washed and the scales are removed and placed in a tank of clear water for final cleansing, after which the fish are cut transversely in sections of the right length to allow them to fit in the cans. The pieces are then forced by machinery into cans, which are then topped and soldered, and then tested and sent to the bath-room for their first cooking. This is done in retorts made of heavy plank, well bolted to sustain the steam pressure, or in retorts made of iron or steel plate. The cooking must be sufficient to crumble the bones.

Second Test.—The cans are then tested by the process known as "blowing" or "renting." A small perforation in each can permits the escape of the steam, after which it is placed in a retort for final cooking. Grease or dirt is then removed in a lye bath, after which the cans are lacquered and labeled, and are then ready for the market.

Sardine Canning.—This industry thrives along the southern and eastern coast of Maine, chiefly at Eastport, Robinson, Lubec, Jonesport, East Lamorin and Camden. The process is quite complicated. The fish are fried in oil and then placed in a can with a solution chiefly of cottonseed oil. The sardine is also put up in mustard, spices and tomato sauce. Eels, herring, menhaden, smelts, sturgeon, halibut and Spanish mackerel are also canned.

The general method is divisible into five processes: First, plain, boiled, steamed or otherwise cooked; second, preserved in oil; third, preserved with vinegar, sauces, spices, jellies, etc.; fourth, cooked with vegetables; fifth, preserved by some other process. In the first class come salmon, mackerel, halibut, lobsters and clams; second class, sardines; third class, herring, which are sold as "brook trout," eels and sturgeon; fourth class, fish chowder, clam chowder and codfish balls.

The Canning of Oysters.—Originally oysters were opened by hand. Next, they were well scalded, and later steamed; next came the shucking process, in which they are placed in cans of iron framework holding perhaps 20 bushels; the cars are run from the wharf to a steam-tight box 15 to 20 feet long and fitted with appliances for admitting steam at any desired pressure. The steam is turned on for fifteen minutes and then the cars are run out into a shucking shed where workmen easily and rapidly remove the shells. Next they are washed in cold water and filled into cans, weighed and hermetically sealed. The cans are then put into a cylindrical basket and lowered into the "process kettle," where they are steamed until all germs of fermentation are killed. They are then taken out, cooled in a large vat of cold water and finally labeled and packed. The cost of handling a bushel of oysters at Baltimore is about 29 cents.

There are 39 establishments engaged in canning oysters, employing 5,122 workmen. The value of the product was $3,670,134, and the number of pounds canned, 22,196,976 in 1900.

Canned Products.—Among the products canned and preserved are tomatoes, corn, peas, beans, pumpkins, sweet potatoes, okra, succotash, pears, peaches, apples, blackberries, strawberries, raspberries, apricots, cherries, plums, prunes, raisins, and pineapples; sardines, clams, mackerel, shrimp, crabs, smoked fish and salted fish, oysters, etc.

The chief canning centers in the order of the volume of business are Baltimore, Md.; San Francisco, Cal.; Chicago, Ill.; New York City, N. Y.; Indianapolis, Ind.; Boston, Mass.; Los Angeles, Cal., and Portland, Maine. Baltimore is called the cradle of the industry.

Order of Importance.—In canned and preserved foods the order of preëminence of States is: Tomatoes—Maryland, New Jersey, Indiana, California, Delaware and Ohio. Corn—New York, Illinois, Iowa, Maryland and Maine. Peas—New York, Maryland, Wisconsin, Indiana. Beans—Maryland, New York, Indiana, Illinois. Pears and peaches—California comes first. Apples—New York. California and New York furnish 87.2 per cent. of the dried fruit.

Comparative Summary of the Fruit and Vegetable Preserving Industry.

	1880	1890	1900
Number of establishments ..	411	886	1,808
Capital invested	$8,247,488	$15,315,185	$27,743,067
Wage-earners	31,905	49,762	36,401
Wages paid	$2,679,960	$4,651,317	$8,050,793
Value of products	$17,599,576	$29,862,416	$50,668,313

Car Builders and Car Building.

Primitive Cars and Shops.—When Robert Stephenson ran his "Rocket" out of his little foundry on to the primitive coal-road track in England, a dozen decades ago, he laid the foundation of an industry which now ranks among the greatest in the world. The early passenger cars were simply coaches on wheels, difficult to enter and inconvenient to ride in. The modern railroad car is an American conception. Very soon after the first few short railroads were built, the American car builder rose into view. Crude shops for making railroad cars were early established at Boston, New York, Albany, Philadelphia and elsewhere, and as soon as railroad building began to extend westward, shops were started at various points along the new lines. These plants were but little more than huge carpenter shops, equipped with the best appliances then available, and the mechanics were mostly carpenters and foundrymen with no special experience outside of their crafts as they had practiced them. Cars were then built without accurate knowledge of the requirements to which they would be subjected and the wheels contained defects of structure, of which poorly-constructed roadbeds frequently made short work.

Rapid Development.—The necessities of railroad service, however, soon developed a type of men who were equal to the new demands, and railroad cars soon appeared of greater weight, of more suitable material, and with wheels capable of withstanding the jars, strains, shocks and continued service, which the rapidly growing traffic demanded.

Scientific Car Building.—It is within only comparatively recent years that correct conceptions and understandings of car construction have gained solid footing. To-day car building is reduced to a scientific basis. Almost everything entering into car construction is submitted to a series of tests under specially devised mechanical appliances. The strength of the timber used is known, the material of which the wheels are composed is as carefully compounded as a physician's prescription. Methods of constructing the framework have been laboriously worked out under practical superintendents and foremen. The steel and iron work is known as to its breaking strength as accurately as the strength of filaments of silk are understood.

First Car Built.—The first passenger car was constructed in 1814, and was in appearance a stage coach mounted on flanged wheels. The first freight car was used on a road between Quincy and Boston, Mass., to haul stone for the erection of Bunker Hill Monument. Crude passenger and freight cars were built for the few scattering railroads built along the Atlantic coast between 1830-40.

What Led to Strong Car Building.—It was the speed of locomotives that drove the early car builders to do better work, and which brought into use a more stable car frame, a flexible truck and improved brakes, chilled cast-iron wheels, and new shape of the thread and flange.

Steel Springs.—India-rubber springs, used for twenty years or more, were supplanted with steel springs; the early cars had no raised roofs and the windows were glazed in solid. Car ventilation was not thought of.

Improvements in Traveling.—Later on came the Pintsch system of lighting, the dining-car, the Pullman car vestibuled, the Westinghouse air-brakes and new couplers, of which to-day there are 7,000 kinds patented, but only a few in use.

Freight Cars.—Specialization is the feature of freight-car construction to suit varied requirements of traffic, from ordinary merchandise to refrigerator, cattle, fruit and other cars. Within a little more than a decade the steel freight car has gained general acceptance, and the Pressed Steel Car Company, of Pittsburg, is now using over 2,000 tons of steel per day in their construction, and has recently practically doubled its capacity. The average freight-train load increased during the last decade from 175 tons to 243½ tons in 1880, and 1,800 to 2,500 ton loads and now hauled. In the census year 144,505 freight cars were built and 8,376,769 cars repaired. The total value of new equipment for railroads that year was $308,748,457.

Related Industries.—The railroad system has resulted in the building up of a great number of related industries which furnish employment to an army of workmen and to many hundred millions of capital. It is the most powerful factor in modern civilization in the stimulation and organization of energy.

Master Car-Builders' Association.—The standardization of railroad car building has resulted in the adoption of uniform methods and rules in numerous details through the agency of the Master Car Builders' Association as well as of some other associations, the former representing every important railroad in the United States. Annual conventions are held at which papers and reports are read and discussed, which deal with mechanical progress and better and more economic methods of doing work. Among many improvements made through this association is the coupler for freight cars, known as the M. C. B. coupler, which represents the concentrated inventive talent of many hundreds of coupler inventors. Through the farseeing mechanical skill of this association, the traffic-carrying capacity of the railroads of the United States has been vastly improved. Standard lengths of cars have been agreed upon, practically uniform construction methods have been formulated, and capacity has been greatly increased. Car construction has been adapted to traffic necessities to the end that the greatest quantity of freight can be expeditiously handled at minimum cost.

Freight-Car Building. — The outcome of this expansion has been the virtual building up of a separate industry with its own rules, methods and standards. The annual production of freight cars has grown from a few hundred per year, fifty to sixty years ago, to an annual output of 150,000 cars or over. It is shown by the fifteenth annual report of the United States Intercommerce Commission for the year ending June 30th, 1903, that the total number of cars in service was 1,640,185, an increase over the previous year of 89,352. The cars were classified as follows: Passenger service, 36,987, an increase of 1,018; freight service, 1,546,101, an increase of 81,773, and company's service, 57,097, an increase of 6,561 over the previous year. The number of cars in use for one thousand miles was 8,195, of which 185 were passenger cars and 7,725 were freight cars. As compared with the previous year the increase in freight cars was 237 for one thousand miles. The repairing branch has become an important feature, and each railroad company has repair shops established at convenient intervals along its lines where damaged cars can be restored. The supplying of equipment for this purpose has resulted in the building up of a large subordinate industry divided into perhaps a score of branches.

Advantages of the Steel Car.—The demand for steel cars is only limited with the facilities for supplying them. The increasing cost of timber and lumber, the decreasing cost of iron and steel, the greater endurance and greater carrying capacity of steel cars over wooden and the minimizing of repairs, with other practical considerations, have led to a very strong preference of railway managers for steel cars over wooden. The greater ability of steel cars to endure the severe conditions and requirements of the service are points in their favor. The use of lumber for cars, relatively speaking, is declining, and it is the consensus of opinion that each year will witness an increasing tonnage carried by steel cars over wooden. The industry is only in its infancy.

Statistics.—A comparative summary of the shop construction of cars by steam railroad companies shows the following:

	1890	1900
Number of establishments	716	1.296
Capital invested	$76,192,477	$119,580,273
Wage-earners	106,632	173,652
Wages paid	$60,213,433	$96 062,329
Value of products	$129,461,698	$218,238,277

The building of cars for railroad and street purposes by other than steam railroad companies is as follows:

	1880	1890	1900
Number of establishments	130	166	193
Capital invested	$9,272,680	$48,460,687	$106,721,188
Wage-earners	14,242	35,148	44,063
Wages paid	$5,507.753	$18,579,304	$23,342,763
Value of products	$27,997,591	$76,352,199	$107,186,359

Car Couplers and Brakes.

Coupler and Brake Patents.—The granting of over 10,000 patents for car couplings and brakes since the introduction of railways into the United States indicates more than mere words could tell the importance of the functions of couplers and brakes. To the outsider it doubtless is a matter of wonderment how ten thousand men could think of so many ways of connecting cars and providing appliances for stopping them. The fact that so many men have secured patents for these purposes proves the extraordinary importance of the problem. And yet the final achievement is nothing more than a device by which one car is coupled to another, in one case, and in the other a device for applying a force to wheels to stop cars in motion or to check speed.

Car Couplings.—Car couplings are almost without number. Out of the thousands which have been patented and urged upon railway managers for adoption, only a few have survived, the most prominent being known as the "M. C. B.," or Master Car Builders' Coupler. This coupler represents the doctrine of the "survival of the fittest," and is now in use upon the greater proportion of the railroad mileage of the United States. The coupler is fundamentally a simple piece of mechanism, but the conditions to which it is subjected have made it a most difficult matter to evolve a device which would meet all the demands made upon it.

The Automatic Coupler. — The automatic car coupler of the vertical type, in which there are means for automatically throwing and holding the knuckle in open position after the locking device has been withdrawn, obviates the necessity of the entrance of the railway employé between the cars. This, of course, is the objective point of all the couplers, but very few of them stand the strain when submitted to use.

Car Buffers. — Intimately connected to the coupler is the car buffer, and in one sense it might be, in a remote sense, regarded as a part of it. Fluid-pressure car buffers operate by a constant supply of fluid under pressure, provided by a pump or train-pipe, whereby the pressure against the buffers may be maintained. These devices serve to minimize shocks and strains and prolong the life of rolling stock.

Vestibule Cars.—Vestibule trains in which the cars are connected to one another by enclosed passages, which at their meeting ends are provided with yieldingly supported door-like frames engaging one another by frictional contact, are the subject of various patents. Many of these devices have been introduced on the larger railway systems, and they afford passengers a sense of ease which warrants their general introduction.

Trussed Frames.—In order to fulfill the extraordinary demands of the railroad service of the present day, the car frames have a trussed structure, which is built up of rolled steel plates, angles and channels, which enable the body of the car to offer great resistance to telescoping or crushing.

Strains and Stresses.—The railway systems of the country have adopted the very best inventions looking to the safety of travel and to the permanency of their own property by the use of devices and means which resist the strains and stresses incident to the rapid transportation of passenger and freight traffic. These protecting devices are apparent in every department of railroad construction, car and engine building, from the ties and rails on the roadbed to the locomotive headlight.

Railway Brakes.—Over 4,000 patents for railway brakes have been granted. In an automatic air-brake system the essential features are an air-pump, a main reservoir and engineer's valve, all on the locomotive; an auxiliary reservoir, a triple valve and a brake cylinder upon each car; a train-pipe extending from the engineer's valve throughout the length of the train and adapted to the action of the triple valve, to be thrown into communication with the auxiliary reservoir or brake cylinder, the triple valve being controlled by the engineer's valve through the variation of pressure of the air in the train-pipe.

Results Accomplished.—This system of controlling the movement of freight and passenger trains from the locomotive engine by the engineer revolutionized former methods, increased the degree of protection to life, rendered greater speed possible, and reduced the time and cost of bringing trains to a standstill. The invention which utilizes the pressure of the air is one of the most practical and most important inventions of the age, the chief credit of which is due to that king among mechanics, George Westinghouse.

Control of the Air-Brake.—When two or more locomotives are connected together to haul a train, the control of the air-brake system is with the engineer of the head locomotive and the brake-controlling apparatus of the second locomotive is cut off. A patent granted January 16th, 1900, shows a device for effecting a greater co-operation of the air-brake mechanism of locomotives when double-heading.

Cast-Iron Brake.—A cast-iron brake-shoe has been invented in which a metal insert is secured to the face of the shoe by casting. The liability to breakage has also been lessened by casting the shoe with a wrought-iron back. Another patent uses metals of different degrees of hardness by casting the shoe with ductile metal netting in it.

No other interest in all the multiplied branches of industry in the United States is as well safeguarded as railroading. Mechanical genius, it might not be inappropriately said, has well-nigh exhausted itself in the mighty task of devising means and methods for safety in travel. Aside from those terrible disasters against which it seems to be impossible for human foresight to provide, the loss of life and injury to persons through the direct culpability of railroad management is reduced to a percentage that reflects favorably on railroad managers.

Carpenters and Carpentry.

Early Carpenters.—Zacharia, first chapter, 20th verse, says: "And the Lord showed me four carpenters." Ancient history, sacred and profane, contains numerous references to the carpenter and his craft. The craft has been honored above all others in this era by being the one chosen by the Great Master. Just how the early carpenters laid the foundation of their craft history does not say, but certain it is that the carpenter was, perhaps, the first mechanic who pointed the way to the human race in the direction of civilizing agencies. The skillful carpenter studies principles of physics, the nature of wood, its uses and fitness and how best to unite it to conserve the purposes of comfort and convenience.

Joints and Fastenings.—The subject of joints and fastenings is one which engages his most serious attention. Five elementary considerations under this heading are: (1) To cut the joints and arrange the fastenings to weaken the pieces of timber they connect as little as possible; (2) to place each abutting surface in a joint as perpendicular to pressure as possible; (3) to proportion the area of each surface to the pressure it has to bear to be safe under heaviest load and to distribute stress uniformly; (4) to see that the fastenings are of equal strength with the pieces they connect; (5) to place the fastenings in each piece of timber so that there shall be sufficient resistance to the giving way of the joint by the fastenings sharing or crushing their way through the timber. Joints are used to lengthen ties, struts and beams under cross strain and for beams bearing on beams, for beams on posts, for posts on beams, for connecting struts with ties and struts with posts.

Terms Used in Carpentry.—Beams are joined by lapping, fishing and scarfing. Halving, beveled halving, dovetailing, notching and double notching, cogging and mortising are operations with which the carpenter soon becomes familiar. The tusk or shouldered tenon gives the tenon as deep a bearing as possible at the root without greatly increasing the size of the mortise. The mortise is, if possible, placed in the neutral axis. Double tenons are often used in joinery, but they should be avoided in carpentry. A coggle is a short tenon to prevent lateral motion. Where a whole end of one piece of timber is let in another it is "housed."

Other Terms Used.—Dovetail tenons are those in which one side of the tenon is stayed so as to form half a dovetail, the other side being straight; notched tenons have one side notched, the other straight. Suspending pieces are used for supporting beams below them. Wedges are often used to keep a tenon tightly fixed. Keys are wedges of hard wood and curled grain, inserted in a joint and driven gently home, so as to force the parts into the position they will eventually occupy. Pinning is the insertion of a pin of hard wood or iron through the timber forming a joint to prevent it from separating, or through a tenon to keep it from drawing out the mortise.

Still Other Terms.—Draw-boring is an arrangement for keeping the shoulders of the tenon quite tight up to the cheeks of the mortise and for tightening pinned joints generally. Trencils are pieces of hard wood used like nails for fastening boards to beams and for forming strong joints. Bolts give additional security to joints, but they weaken the beams through which they pass. They are useful because of the ease with which they can be tightened up. Plates are used to prevent the sharp corners of the nut from pressing into the timber. Straps are often used instead of bolts. Heel straps are used to secure the joints between the inclined struts and horizontal beams. Branched straps are frequently added to strengthen angle joints.

Floors.—Floors are classed as single, double and framed. In double floors the budging joists are supported by intermediate supports called binders. These floors are in some ways complicated and are bad form of construction, as the binding joists bring the whole weight of the floor and its load to bear on a few points. The space between the two binders is called a "case bay," and that between the binder a "tail bay."

Features in Construction.—Carpenters see to it that girders are weakened as little as possible by mortises or joints. Wall plates distribute the weight thrown upon them by the joists, and they may rest on corbels or upon a corbel course to prevent decay. Cogging gives the joist a good hold upon the wall plates, and these wall plates are dovetailed together where they meet at the angles of a building, but there are many objections to dovetails. Joists more than ten feet long are often strutted to make them stiff, but wooden kets are sometimes used instead of struts, which, to be effective, should be in straight lines along the floor.

Difference in Rules.—In the Eastern States the bottom of the floor joists is almost always cross-furred with 1½-inch straps. This rule is not followed in Western States. Wood framing has developed much literature. Until within a few years stirrup irons were largely used, but a better method is to tie the end of the header to the trimmer with a joint bolt. Authorities believe that built-up girders are better than solid girders. In these days of steel construction the work of the carpenter has been restricted, but there is a vast field of opportunity in the construction of large residences, where the highest skill finds room for exercise.

The Saw and Planing Mill.—The work of the carpenter has been simplified on one hand and complicated on the other by the developments in the industries and in the art of construction. The saw mill and planing mill furnish him with dimension stuff cut to desired thickness and length. Material for interior finish is supplied ready to be put in place. The carpenter shop has ceased to be the center of calculation and preparation, this work being done by the architect or builder or the mechanical or constructing engineer.

Iron and Steel in Carpentry.—The utilization of clay in the form of brick, of stone for foundation work, of iron and steel for framework, of cement and concrete for various and broadening purposes, all gradually converging in their influence, shifted the carpenter somewhat from his former position, and while lessening his importance in one direction, increased it, and that vastly, in another. Great as are the improvements in construction, valuable as are iron and steel and stone and other material, lumber is, and must remain, an important factor in construction. It devolves on the carpenter to see to it that the woodwork is properly associated with the stronger and heavier materials in ceilings, partitions, floors, stairways, halls, etc. The handicraft of carpentry has improved under the pressing necessities developed in modern forms of construction. There are numerous requirements to be met which did not formerly exist. The use of pipes for water and gas, and of wires for electrical purposes, calls for nicer discrimination and care and taste on the part of the carpenter, even though these devices and conveniences are not handled and installed by him. He has to provide for them.

Ornamentation in Carpentry.—Another requirement which strengthens the position of the carpenter is the taste and demand for ornamentation in dwellings and buildings of all kinds. In the execution of this class of work he is ably assisted by the wood-worker, who, with cunningly devised machinery, produces all manner of construction needs in lumber which goes to beautify the interior of buildings and dwellings.

Wood Working.—The planing mills and the wood-working factories are machine carpenters, doing the work they formerly did in a large degree. Carpentry is now largely a matter of assembling of material and of predetermined pieces, based upon calculations embodied in tables which prescribe what kinds and qualities of lumber are used. Carpentry has become scientific in its application, but calls for less individual skill and greater aggregate intelligence. The remarkable expansion of construction has opened wide avenues for profitable employment in this craft, and within recent years organization has assumed remarkable and sometimes dictatorial cohesiveness, which the workmen feel is warranted by the justice of their cause.

Comparative Summary of Carpentry.

	1880	1890	1900
Number of establishments..	9,184	16,917	21,315
Capital invested............	$19,541,358	$81,542,845	$71,327,027
Wage-earners................	54,138	122,952	123,985
Wages paid..................	$24,582,077	$79,355,029	$71,049,737
Value of products...........	$94,152,139	$281,195,162	$316,101,758

Carpet Makers and Carpet Making.

First Makers.—The first American carpet manufacturer, of whom there appears to be authentic record, was William Peter Sprague, who established a small carpet factory at Philadelphia in 1791. He attracted wide-spread attention to the industry by the weaving of an emblematic carpet for the United States Senate Chamber in Philadelphia and which was regarded as a fine specimen of workmanship. For many decades carpeting of all kinds and in all countries was woven on hand looms. It is due to the inventive genius and impressible spirit of American textile machinery mechanics that the industry within such a comparatively short time has reached such stupendous proportions.

Power Loom for Weaving. — The first great practical impetus to carpet making on a factory basis was imparted by Erastus Brigham Bigelow, who, in 1839, invented and put into use a power loom for weaving two-ply ingrain carpeting, which at that time was laboriously woven on hand looms, at the rate of seven to eight yards per day. Bigelow looms, soon after installation, produced over three times that quantity. John Haight had five years before invented an impracticable ingrain power loom in which the patterns would not match, and it was therefore abandoned, but this failure was the basis of Bigelow's success.

The Ingrain Loom. — The next move was to apply the principles to power looms for weaving body and tapestry brussels, then produced on hand looms at the rate of three to four yards per day. The new loom produced eighteen yards and this capacity has been later increased many fold. Mr. Bigelow perfected his ingrain loom in 1845 and his brussels loom in 1848. British carpet manuafcturers purchased his patent rights and entered upon carpet making on a much more extensive scale.

The Bigelow looms have been constantly improved from that day to later times. Among the more important improvements may be mentioned the Babbitt, Murkland and Duckworth ingrain looms.

The merit of these improvements consisted in rapidity and introduction of a great variety of shading by means of skillfully arranged sliding and revolving shuttle boxes.

A Notable Improvement. — Another invention was an improved actuating wire motion for removing wires from pile fabrics during the process of weaving. The improvement known as the "double" shed movement was a mechanical combination by means of which the wires were withdrawn and the threads simultaneously placed in the fabrics, thereby obviating the necessity of forming an independent shed for the wire and two independent sheds for the threads, thus reducing the number of revolutions for the completion of one loop or pile.

The Moquette Loom.—The American moquette power loom was invented by Halcyon Skinner in 1873. It has been much improved by numerous patents on both sides of the Atlantic. The process is simple and ingenious. In 1882 George Crompton, of Worcester, Mass., invented a moquette loom of great ingenuity, in which the pile was cut with a wire, using only one cutting wire. Two of the most valuable appliances in connection with carpet weaving are the Lyall positive motion shuttle and the Lyall cop. By means of the positive motion shuttle, carpet of practically unlimited width may be woven. The Lyall cop permits a condensation of the yarn for insertion in the shuttle without the use of a spool.

The Features of Carpet Power Looms.—The distinguishing characteristics of American carpet power looms are their ingenious simplicity and lightness, combined with strength, rapidity of weaving and compactness and so constructed that they can be operated by women and girls. By the use of power looms, the quality and style of carpeting has been greatly improved. Remarkable progress has been effected in every branch. Wilton carpeting and velvet carpeting have greatly increased under the magic touch of inventive genius. Body and tapestry Brussels representing the loop-pile fabrics have made wonderful strides. It is said that body Brussels was introduced by Isaac Macauley in Philadelphia in 1815. Joseph Crawshaw is credited with having introduced tapestry Brussels in 1848 near Boston.

Damask, Venetians and hemp carpeting have improved rapidly under the same general influences. The manufacture of Turkey or Smyrna carpetings and rugs has latterly become a most important industry, and rag carpeting is also justly recognized as an important feature.

Artistic Designs. — The production of artistic designs occupies the attention of a large body of skillful designers. Early in the industry, designs were obtained from abroad, but American designers now lead the world. The designing department of most of the larger factories represents quite an item of expense. American styles of carpeting are remarkably varied and include every species of decoration. Natural floral styles and large figures in bright colors have been extensively superseded by flat treatment with subdued color effects, and the conventional styles which have been so long advocated by "high art" devotees have been largely adopted by the general public. It may be said that no branch of textile manufacture has made greater progress than carpet making in America. The mechanical appliances now in general use represent the highest conceptions of skill and ingenuity and they deserve to be regarded as indicative of the supremest effort of the human mind at its present stage of development in this most interesting field.

Carpet Production. — In Massachusetts there was a slight falling off in production in the last decade, and in New York and Pennsylvania a slight increase. The carpet-producing capacity is now presumably equal to any probable demand, but the increasing cost of raw material and labor has brought about small increases in factory cost.

The materials consumed in carpet making are foreign and domestic wool, scoured wool, hair of various kinds, cotton, shoddy, waste, woolen and worsted yarns, mixed yarn, cotton and linen yarn, and jute yarns.

The production is two and three-ply ingrain, ingrain art squares, Venetian, body Brussels, tapestry Brussels, tapestry velvet, Wilton and Wilton velvet, Axminister, moquette, Smyrna, cottage, Dutch and rag carpet.

The growth of carpet production in the last half century was from $5,401,234 in 1850 to $48,192,351 in 1900. The growth of the popularity of velvet or cut-pile carpets has lessened the demand for tapestry and body Brussels carpets.

Philadelphia is the greatest carpet-making center, and provides three-eighths of the capital and produces one-half of the total value of carpets and rugs sold. The factories of New York and Massachusetts produce finer qualities.

The total production of carpeting in the United States in 1900 was 75,551,861 square yards, including 8,984,194 square yards of rugs. The production of rugs during the past ten years has more than doubled.

Comparative Summary of the Carpet and Rug Industry in the United States for Three Decades.

	1880	1890	1900
Number of establishments	195	173	133
Capital invested	$21,468,587	$38,208,842	$44,449,299
Wage-earners	20,371	28,736	28,411
Wages paid	$6,835,218	$11,122,259	$11,121,883
Value of products	$31,792,802	$47,770,193	$48,192,351

Rag and Wood Carpets.—The above figures relate only to carpets and rugs other than those made of rags and wood. The rag-carpet production was $1,714,480 in 1890, and $1,993,756 in 1900. The wood-carpet production was $511,700 in 1890, and $1,056,702 in 1900.

Carriage and Wagon Makers.

History.—The early history of carriage and wagon making in the United States is one of shop struggles with crude tools. The earliest prints extant show quite creditable attempts at wheel and body making. Very early in colonial history heavy coaches were imported for "state" purposes and "state" occasions. A vehicle was for a very

THE VEHICLE INDUSTRY

	Nº OF ESTABLISHMENTS	WAGE EARNERS	WAGES PAID DOLLARS	VALUE OF PRODUCT DOLLARS
BICYCLES & TRICYCLES	312	17,525	8,189,817	31,915,908
BICYCLE REPAIRING	6,388	5,749	2,505,974	13,766,033
AUTOMOBILES	109			4,899,443
CARRIAGES & WAGONS	7,632	62,540	29,814,911	121,537,276
CARRIAGES & SLEDS (CHILDREN'S)	77	2,726	1,090,296	4,289,695
CARRIAGE & WAGON MATERIALS	588	15,387	5,987,267	25,027,173
CARS, BY RAILWAY CO'S	1,296	173,652	96,062,329	218,238,277
CARS, BY OTHERS.	193	44,063	23,342,763	107,186,359

THE AUTOMOBILE INDUSTRY.

This Industry has made Phenominal Strides since the Census Year Current figures for the United States are –

Nº OF MANUFACTURERS, 300

YEARLY OUTPUT 10,000 VEHICLES

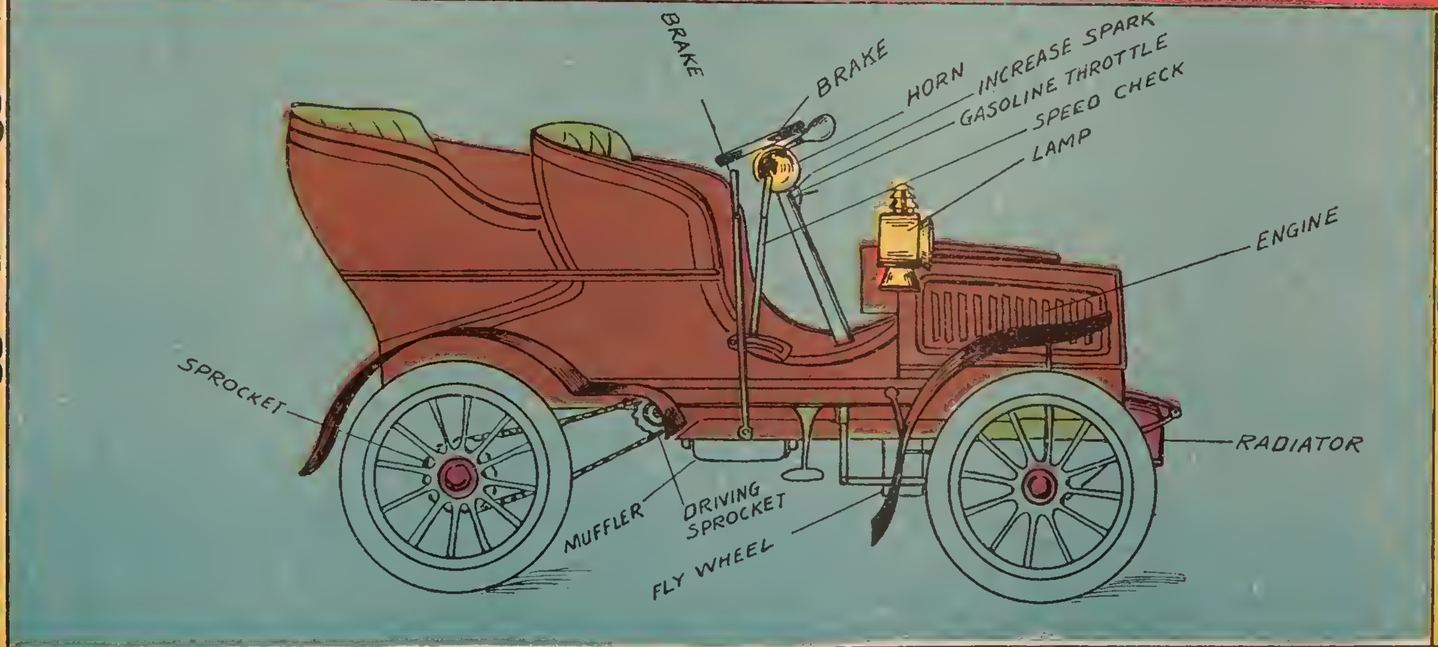
MANUFACTURERS OF PARTS 2,000.

VALUE $10,000,000

ESTABLISHMENTS OFFICIALLY REPORTING :-

	ESTABLISHM^TS REPORTING	Nº OF VEHICLES	VALUE	AVERAGE PRICE
GASOLINE	50	10,040	$ 10,431,250	$1,000
STEAM	27	6,180	$6,525,500	$1,056
ELECTRIC	13	1,835	$2,262,500	$1,233

VEHICLES IN UNITED STATES ABOUT 40,000.



long time a luxury not to be thought of by the "people." It was in New England that the carriage shop had its origin, and soon afterward shops appeared in New York, Philadelphia and elsewhere. The original "coach" idea was adhered to for a long time, but the necessities of travel from town to town forced a departure from the old style. The industry in its infancy largely depended for support on coach travel, and the workmanship in many respects has not been materially improved upon to this day.

First Innovations.—The first departure from coach construction was the production of a one-horse vehicle, which corresponded in many respects to our present buggy, or, as it was then called, the one-horse shay, which Oliver Wendell Holmes has immortalized in verse as the "one-hoss shay." But new designs soon appeared, involving the characteristics of the present buggy and other light forms of vehicle intended to be drawn by one horse. Quite a demand sprang up for these vehicles, because of their moderate cost as compared with a coach, and because of their utility and convenience. These vehicles were then and for decades after laboriously evolved in the same shop, by the same mechanics, by means of a crude forge, drawing knife, plane, hammer and other primitive appliances, the use of which, to create a vehicle, called for and developed a high degree of skill. Dependence was had on England for very little. Wheels, bodies, shafts, iron work—all came out of the same shop, and the finished vehicle really represented in a sense a triumph of mechanical genius.

Mechanics of To-day.—The carriage and wagon builders of to-day constitute a class of mechanics who deserve credit for rare genius. The victory they have won consists in the doing by machinery that which had been done by hand, including a number of operations which to an outsider would appear impossible to be done excepting by hand. There are few industries wherein machinery comes so nearly doing the work of human fingers as the vehicle industry. Take a spoke. To make a spoke calls for seven or eight different operations, all of such nice adjustment as to appear to require the delicate human touch and keen calculation. But the demon of mechanism attacked the spoke. At first the service of one mechanic was dispensed with, and machinery did that work at less cost and in less time; then another mechanic was dismissed from spoke-work and sent to other labor, and so on until the whirr of machinery seems to say to the mechanic of flesh and blood, "Begone!"

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Machine vs. Hand-Work.—Thus, step by step, mechanism usurped the work of fashioning the spoke out of the square stick into the perfected spoke. This is only typical. Similar processes were followed with reference to the gears under the vehicle. Work that for decades was laboriously done by hand is now expeditiously, rapidly and accurately done by machinery.

Details of a Grand Whole.—Wheels and their various parts—hubs, felloes, etc.—are similarly turned out by machinery operated with such speed as to tax the mind and body of the attending workman to feed and supply it. The modern vehicle represents in its entirety over fifty trades and as many varieties of skill. The carriage builder proper is merely an "assembler," to coin a word. All the various "units" are provided by separate branches of the industry, wherein greater skill and excellence are developed through exclusive attention to the production of specific parts.

Vehicle Plants.—The use of machinery has resulted in the building up of vehicle plants of great producing capacity. The largest plant, located in Indianapolis, Ind., has a capacity for 150,000 vehicles per annum, which is practically 3,000 per week, or 500 per working day. Such a plant represents a high state of industrial organization. Many plants range in capacity from 5,000 to 50,000 vehicles per annum.

Number of Carriage Builders.—There are 36,184 carriage and wagon builders in the United States, including repairers; 510 wholesale manufacturers of carriages and wagons; 24,990 carriage and wagon dealers; 3,956 manufacturers and dealers in materials; 398 sleigh manufacturers; 398 automobile manufacturers; 739 automobile dealers; in all, 69,054 firms and individuals engaged in carriage, wagon and automobile construction and repair and their sale.

Leading Inventions.—Among the first epochal improvements in carriage construction was the Collinge axle, introduced perhaps a century ago. Prior thereto axles were tapered, but the Collinge axle was made straight. None of the improvements made since have equaled this innovation in its importance. Boxes on this axle fit more snugly, have less vibration and friction, and wear longer. This axle is ideally correct, and no later improvements have surpassed it, although improvements have been made in the quality of material of which axles are made.

Hub and Wheel Improvements.—The hub, in its relation to spokes, has received much attention of late, and various patented hubs, or rather wheels, have appeared on the market, among which may be deservedly mentioned the Sarven, Warner, Sweet and Olds. The essential feature of these improved wheels is in the manner of their attachment to the hub, the objective point being to secure the highest degree of rigidity and the greatest degree of freedom from jar or jolt. To that end each spoke, as it enters its socket in the hub, is supported or sustained by iron, which prevents movement or the tendency to vibrate. An additional feature in the improved hub is what is known as Sweet's concealed band, a device which has for its object the lending of additional compactness, strength and solidity to overcome the elasticity due to the existence of fibre, grain and the microscopic spaces characteristic of all timber. In consequence of the adoption of these devices, the hub is somewhat larger than the plain hub on light carriages. They are chiefly used on wagons, drays, omnibuses and vehicles carrying heavy loads, and are not ordinarily used on fine carriage work, because of their bulky and uninviting appearance, and also because such a degree of strength is not essential in carriage work.

Other Mechanical Features.—The other essential features of a vehicle are the body gears, reaches, springs, poles and shafts, on all of which repeated improvements and innovations have been made, mainly with the view of securing the greatest lightness consistent with the strain and load. The mechanical center of gravity is a matter of which the carriage draughtsman and builder never lose sight. The ideal vehicle, although made up of many pieces of wood and iron, is essentially one solid mechanical structure from end to end.

Varieties of Vehicles.—The varieties of vehicles are many, and styles are many—practically endless. Among the leading varieties may be mentioned victorias, surreys, phaetons, cutunders, rockaways, runabouts, buggies and buckboards, and various combinations of these varieties manifested in shape and contour, each possessing some more or less distinctive feature in shape, style or trimming.

Points of Difference in Vehicles.—The gig is perhaps the oldest of existing types of vehicles. The dog cart accommodates four persons, back to back, and has appliances for shifting the body. It was originally intended for hunting purposes, and carried dogs; hence its name. The sulky is used for speedy trotting or pacing horses, and is peculiar to the United States. The road cart is a modification of the sulky with conveniences for carrying articles. The Hansom cab hangs between the wheels, with driver's seat behind and above. The four-wheeled covered carriage is intended to carry four inside and two outside, and the body is suspended on elliptical springs or in combination with C-springs, which is called "double suspension." The Landau takes its name from the town in Austria where it is supposed it was first built. It has a falling top, and when of leather is called a "leather quarter" Landau, or with glass, a glass front.

The Brougham.—The Brougham, called after Lord Brougham, who first asked for a vehicle of special construction, is a low-hung, close-paneled, straight glass-front carriage for two persons inside and a paneled seat for coachman in front. When the body is made for more than two inside, it is called an extension front.

The Rockaway.—The Rockaway is after the Brougham style, with sides either curtained or paneled, the roof extending over the driver's seat, which is on the same level as the inside seats. It is made to carry four or six persons, and the body is hung on two, four or six elliptical springs. It is a light carriage, and derives its name from Rockaway Beach, a popular resort on Long Island, N. Y. It is sometimes spoken of as a "carryall." This type of carriage has been greatly developed as a family carriage, and is spoken of as a coupé or Rockaway coach.

The Barouche.—The barouche is of coach type, with the upper half of the body cut off, and is finished with a leather hood or top over the back seat. It is made with doors, and is also called a vis-a-vis.

The Cabriolet.—The cabriolet, originally an Italian gig, is now a leather-hooded carriage for two persons, with no door and with a driver's seat.

The Victoria.—The Victoria, named after the late Queen of England, is in all respects similar to the cabriolet, except that instead of a paneled seat for the driver in front, the body is provided with iron loops, which connect it with the front of the carriage. On these loops is constructed the driver's seat.

The Mail Phaeton.—The mail phaeton is a heavy, square, box-body carriage, with hooded seat for two in front and a seat behind for grooms.

Stanhope Phaeton.—A modified form of this phaeton is known as the Stanhope phaeton. The spider phaeton is another modification, and has a front seat supported on two iron loops, which connect with the hind carriage and aid in supporting the groom's seat, which is either an iron frame or paneled.

The Brake.—The brake is a heavy phaeton for gentlemen's driving, and seats from six to twelve persons, including grooms. It derives its name from being originally used in England in breaking colts.

The Buggy.—The buggy is peculiar to this country and Canada, and is a light vehicle with one seat for one or two persons, and with or without a hood or top or a falling top. Formerly all buggies were hung on high elliptical springs, but now are hung low on side-bars of wood attached at their ends to semi-elliptical springs. The term buggy is of Anglo-Indian origin, from Hindi, which means bag, pronounced bug (to move), and in India is used to designate a kind of gig with a hood to screen travelers from the rays of the sun.

The Buckboard.—The buckboard, a variety of the buggy, is of very simple construction, requiring for its construction four wheels, axles, a king-bolt and woodwork. The name was suggested from its capacity to "buck" successfully against rocks and inequalities on the road. It has become latterly somewhat fashionable, with two or four seats, and is finished in fine style.

The Surrey.—The surrey, or family buggy, is a side-bar vehicle made to accommodate four or more persons, and is made in a great variety of styles. The body is suspended as the buggy, and is made in three general patterns, one of long gear to allow stepping in and out between the front and back wheels; another, coupled somewhat shorter, in which entrance to the back seat is had by lifting half of the front seat ; and a third, like the second, but with the additional convenience of dropping the back panel and so shifting the back seat as to permit riding back to back if desired.

Shapes.—There is less opportunity for modifying shapes of wagons, and less or no occasion. The construction of wagons has been practically revolutionized during the past twenty years, with reference to capacity and endurance.

In 1890, 128,726 business wagons were built, of which one-half were delivery wagons; 3,901 automobiles, 445,517 light wagons and carts, 118,221 sleighs and sleds.

Branches of Carriage Building.—The industry has become specialized to a high degree, so that to-day the work of the carriage builder mainly consists in purchasing the various parts or "accessories," as they are termed, ready made, and skillfully putting them together and applying appropriate trimming, and then painting the completed vehicle. Among the important branches are the building of bodies "in the white," the manufacture of wheels, which is again subdivided into industries which supply parts of wheels; gear making, pole and shaft making, "fifth" wheel making, hanger and shackle making, spring making, axle making, tire making and many lesser branches.

Tire-Setting Invention.—An epochal invention in the vehicle industry, and perhaps second in importance to the Collinge axle, is the tire setter, the invention of James B. West, of Rochester, N. Y. This remarkable invention is practically a circular iron press, large enough to receive the wheel to be tired, and actuated by steam or water-power, the smaller sizes being operated by hand. The wheel to be tired is placed in the circular receptacle, and by means of mechanical adaptation the circumference is pressed inward until the tire and the felloes become compact end to end and the spokes are pressed at each end to the farthest limits permitted by the felloes and hub. The substance of the metal tire is compressed similarly until the maximum adhesion is obtained between the iron or steel and the wood which it envelops, thus making an exceedingly compact wheel, free from vibratory action in any part. This work is speedily done, requiring from one to two minutes or less for each wheel. The action of the "setter" is under absolute control of the operator. The economic advantages of this machine have rendered it indispensable in any carriage or wagon shop where considerable work is done.

Conspicuous Features of American Vehicles.—The characteristic feature of American vehicle construction is its lightness. The least amount of material is used that will safely carry the calculated load—consistent, of course, with durability. In this respect American vehicle work has become the admiration of the carriage builders and users throughout the world. Builders have the advantage of iron and steel of rare purity and strength, though much Swedish iron is employed. The quality of most timber used favors the minimizing of that material.

Rubber-Tire Era.—Another epochal event in the development of the vehicle industry is the use of rubber tires, which are either solid or "pneumatic." The commercial introduction of this tire is attributed to Dunlop, and this tire, improved and modified in many ways by numerous inventors, is now in quite general use, the majority of carriages being equipped in this manner.

Ball Bearings.—One important feature deserving of attention is the use of ball bearings in vehicles. This well-known and exceedingly useful and comfortable device is now very largely used to lessen wear, tear and friction, and to increase the comfort of riders.

Good Roads.—An influence for good in this important industry has been the extension of "good roads" and the use of asphaltum in street construction. The inducement to use a horse-drawn vehicle has been greatly strengthened in recent years by the extended and inviting opportunities afforded by good roads in towns, cities and country. The industry has been subjected to frequent expansions and depressions, but since the remarkable expansion of the railway system the demand for vehicles, especially the lighter grades, has reached extraordinary proportions, and which present many features of permanency.

Production.—The number of family and pleasure carriages increased from 841,305 in 1890 to 907,482 in 1900, valued in the latter year at $51,147,630; public conveyances decreased in that decade from 3,200 to 2,316; sleighs and sleds increased from 87,161 to 118,222. In 1900 there were 29,302 two-wheeled carriages made, 20,402 carts, 1,804 dog carts, 1,536 pony carts, 1,492 sulkies, 513,565 buggies, 25,207 phaetons, 29,945 driving wagons, 116,682 road wagons, 22,747 runabouts, 6,735 Stanhopes, 1,466 traps, 1,725 furniture vans, 7,417 drays and trucks, 4,898 dump wagons, 3,155 coal wagons, 797 hearses, 11,788 trade wagons and 1,108 ambulances.

Comparative Summary of the Carriage and Wagon Industry.

	1880	1890	1900
Number of establishments...	3,841	8.614	7,632
Capital invested	$37,973,493	$104,210,257	$118,187,838
Wage-earners...............	45.394	64,259	62,540
Wages paid..................	$18,988,615	$32,665,301	$29,814,911
Value of products...........	$64,951,617	$114,551,907	$121,537,276

Cash Register, The Evolution of the.

The Cash-Register Idea.—The cash register was born on board a ship that plowed her way across the Atlantic on a voyage to England. Among her passengers was a man who had wrought himself up to the highest pitch of nervousness and misery by dwelling on what might happen to his business while he was on the ocean. He had left behind him at Dayton, Ohio, a store that was absolutely without safeguards against dishonesty, and he trembled to think of the possibilities afforded by his unprotected till. There was an instrument in the engine-room of the vessel that recorded each revolution of the propeller, and Mr. James Ritty (for such was the name of the inventor of the cash register) watched it frequently as it cast up the figures. His brain was made fertile by anxiety, and he suddenly conceived the idea that the uneasiness which destroyed so many business men's comfort might be dispelled by some machine that would record the sales made in their shops. The more he thought of this the more the idea grew upon him; and before he had reached England he committed his opinions to paper.

The First Start.—In his frame of mind it was impossible for him to derive either rest or recreation from his trip, and when the ship arrived at her destination he at once returned home.

The First Patent.—A crude affair was put together, patented and introduced in 1879. The machine which resulted from these labors resembled a clock with a dial having two brass hands, one for dollars and the other for cents, with a keyboard along the front. When a sale was made the clerk would press down the key representing the amount of the same, and the hands would fly round to indicate the transaction. Mr. Ritty tried to make this register a total adding one; that is, a machine that would show the total amount of the sales made. However, he never succeeded in accomplishing this; while it would add, it would not add correctly.

Birth of the Cash Register. — This first cash register was fashioned in an old shed in the heart of Dayton, Ohio. The principal machine used in the manufacture of the new instrument was an antiquated lathe, the workers consisting of a man and a boy. What an immeasurable distance there is between this tatterdemalion edifice and the industrial palaces that form the home of the register to-day! How different is this poor equipment and slender staff from the great array of men and machinery that are fast transforming the business systems of the world!

The First Factory.—The early attempts to introduce this valuable device resulted in a number of failures for various causes not connected with its merits. It was not until 1882, when two obscure country merchants in Ohio took hold of the enterprise at Dayton, Ohio, and brought order out of confusion and success out of failure. Within two years—viz., 1884—a factory force of fifty men were kept busy filling orders.

What the Cash Register Does.—It protects receipts and expenditures; protects careful assistants and detects careless ones; enables the proprietor to balance his cash in from one to five minutes; tells him how much and what kind of business each assistant does; induces customers to buy for cash; prevents children and servants from saying assistants overcharged them; pleases customers and retains their trade; saves bookkeeping; very little is required and that is so easy that it can be done in a few minutes; tells which department is making or losing money; furnishes customers with a printed receipt for their purchases; keeps a record of the number of customers daily, showing whether they are increasing or decreasing; relieves the proprietor of many annoying details, so that he has time for important matters; enables each assistant to wait on a great number of customers; prevents disputes between customers and assistants by showing a record of every transaction; advertises the shopkeeper's business at little expense; prevents favoritism to customers and prevents price-cutting.

Patents Secured.—The best-known cash register is the product of over eight hundred patents, containing 18,500 claims, and in its production 5,434 employés are engaged. Over five hundred styles of cash registers are in use and five invention departments are conducted, employing forty-six successful inventors.

Statistics.—The manufacture of this wonderful device has led to the production of much specially devised and most delicate machinery and devices. The largest factory in the United States is now turning out 230 registers a day and has sold 326,000 machines. There are branch factories in Europe and Canada and agencies all over the world, absorbing the services of over one thousand men.

Influence of the Register. — The cash register has revolutionized methods of handling retail trade in many channels. That it has found its way into all civilized countries is not to be wondered at. The leading manufacturing company, the National Cash Register Company, of Dayton, Ohio, manufactures three hundred and fifty varieties of its different principal registers adapted to every possible demand. The getting out of each new machine requires a new set of tools. New cash registers will have to steer their way through these several hundred separate and distinct patents in the United States, and one hundred in Europe containing fifteen thousand separate claims. As an automatically acting machine, it probably stands at the head. The climax of achievement is a machine which gives the name of the clerk who makes a mistake, who takes counterfeit coin, singles out each clerk who takes part. In it each clerk is compelled to print his initial letter. This wonderful machine has simplified the business of recording sales and accounts and stands preëminent as an achievement of ingenuity.

Summary of the Cash Register Industry.

	1890	1900
Number of establishments	5	13
Capital invested	$292,150	$5,137,965
Wage-workers	697	2,015
Wages paid	$396,282	$1,223,966
Value of products	$1,281,500	$5,594,500

Cement Manufacture.

Nature of Cement.—Cement in its broad definition is any substance which makes bodies adhere to each other, but in its commercial sense is a calcined limestone or a calcined mixture of clay and lime for mixing mortar which will harden under water. It is this feature which makes it so highly valuable in engineering and large building operations, where very strong foundations are necessary and where endurance is the chief element in construction. Several clays are used for the manufacture of cement, found in scattered localities and of varying degrees of value for commercial purposes. One of the largest and most valuable deposits is found in Eastern Pennsylvania, and it has given rise to a large and growing industry, the products of which find ready market throughout the United States.

Composition of Cements.—The compositions of cements vary, and their manufacture has given rise to much interesting investigation, experiment and study among manufacturers and cement experts, including civil engineers and others interested in their use in important building and construction operations wherein stone is the principal material used. Discussions on cement in scientific circles have filled volumes with technical details as to manufacturing methods and processes. The extraordinary development of the industries, the expansion of railroad building, the building of bridges, the need of strong and permanent foundations of stone, the building of wharves and docks requiring deep and permanent foundations, all unite to create an enormous demand for cement of the highest possible adhesive qualities under all conditions of use. The industry as it now exists is permanently established, and the markets are being supplied with qualities of cement of high value; in fact, it would appear as though the science of chemistry and the skill of the mechanic have done their best to produce a cement that would serve to sustain structures of most ponderous proportions for all time.

Varieties of Cements.—Cements are of great variety, and the formulas for their production are almost without limit, especially as to use in the minor requirements in the arts and lesser industries and for the household. There are acid-proof cements, cements proof against boiling acids, cements for casks and cisterns, cements for uniting wood to wood, stone to wood, stone to iron and various other materials. There are cements for leather belting, cements for joints, bottle cements, cements for building stone, for joining wood to leather, various chemical cements, cement known as Chinese glue, cloth cements, marble and crockery cements, English Roman cements, fireproofs and floor cements, French cements of various kinds, various glass cements, glue cements, Jennin's cement, Japanese cements, jewelers' cements, London cements, cements for iron and stone, and many others too numerous to mention.

Portland Cement.—Portland cement derives its name from its supposed resemblance to Portland stone when used as a stucco on walls. The materials used in its manufacture are chalk, river mud and clays of certain characteristics, and oxide of iron used in varying proportions. A proportion frequently used is 65 to 85 per cent. of limestone and 20 to 35 per cent. of clay and iron oxide; before being used, the cement is better if kept for a time in a dry place. It hardens rapidly when stirred with water, and possesses great cohesive power, which is diminished by the admixture of sand. When used as a stucco it can be mixed with 3 to 4 parts of sand to 1 of cement.

Rice and Other Cements.—Rice cement is made by mixing rice flour with cold water and gently boiling. Roman cement is made of ordinary clay and lime which is recalcined; the proportions are 3 of clay, 2 of lime. Roof cements are sometimes made of common pitch and guttapercha, 2 parts to 1. Artificial cements are made for sidewalks, which have the durability of stone. For this purpose Portland cement with sand is used, with stone chips, gravel and larger stone. Stonemasons' cement is sometimes made of river sand, litharge, quicklime and linseed oil in specific proportions. Cements for tiled roofs are made with dry sand, whiting and litharge. There are various kinds of zinc cements which are very useful for many purposes.

The minor uses of cement are almost innumerable. One of the strongest cements easily made is by using equal quantities of gutta-percha and shellac melted together and well stirred. A good acid-proof cement is made by mixing a concentrated solution of silicate of soda with powdered glass to form a paste, or a mixture of China clay and boiled linseed oil in proportions needed, or quicklime and linseed oil stiffly mixed together, which will resist both heat and acids. A brick-dust cement is made by melting resin and stirring in brick-dust finely ground and sifted into a putty which runs easily while hot. A cement to stop cracks in glass vessels to resist moisture and heat is made by dissolving caseine in a cold saturated solution of borax. A fireproof cement is made of iron filings 140 parts, hydraulic lime 20, quartz sand 25, sal-ammoniac 3 parts, formed into a paste with vinegar. A good cement for cellar bottoms is made by using 5 parts clean, coarse sand to 1 part of cement. A concrete for foundations is made of 5 parts gravel and sand to 1 part fresh-burned limestone ground to powder without slacking, well turned and shoveled together with sufficient water to slack the lime into a state of very thick mortar. Glue is a very valuable ingredient in many cements, as well as glass and isinglass. A good cement for leather driving-belts is made of 10 parts bisulphide of carbon and 1 part oil of turpentine dissolved in gutta-percha to form a paste. Jannins' cement is a mixture of yellow oxide of lead with glycerine. A cement to attach the brass piece to petroleum lamps is made by boiling 3 parts resin with 1 part of caustic soda in 5 parts of water. To fasten paper to stone, melt together equal parts of asphalt and gutta-percha, and use hot putty made of a mixture of fine whiting with linseed oil or linseed oil varnish. A good cement for roofs is made of 2 parts by weight of common pitch and 1 part gutta-percha. A good steam-boiler cement is made of 2 parts of finely powdered litharge with 1 part of very fine sand and 1 part of quicklime which has been slacked simultaneously by exposure to the air.

Charcoal Making.

Nature of Charcoal.—For many purposes a very concentrated form of fuel is absolutely necessary. All materials used for fuel contain a number of impurities or substances which do not contribute to heat. Coal itself contains ash in varying proportions, which does not contribute to heat, but detracts from it. The same is true of wood and any and all materials used to generate heat. The carbon contained in the materials used, uniting with oxygen, produces heat. The more carbon, the greater the heat. The purpose of submitting wood and coal to certain preliminary processes is fundamentally to drive off those elements which detract from the heating power of the contained carbon. In other words, the objective point is to reduce the carbon into a condition available for ready and unobstructed use. For this purpose charcoal is made, and in the process of preparation water, ash and other elements of an opposing nature are driven off through the process of slow combustion, under conditions which exclude the interference of the air, through which, if permitted to enter, the oxygen in the air would destroy or consume the material which it is sought to conserve for its carbon for heating purposes.

Process of Making.—The processes for converting wood into charcoal have always been and still are of the simplest character, involving very little skill or labor. Different woods possess different values for charcoal purposes, just as coal, though as to coal there are only certain varieties which are available for coking purposes, and are known as coking coal. The processes as applied to wood practically mean the coking of wood. The wood is prepared in convenient shape, and so arranged as to exclude the access of air, in order that the process of separation of the materials contained in the wood may be conducted slowly and in accordance with the chemical laws which hold the materials together. The wood is put to sleep, as it were, while the foreign elements are enticed away, and it is then awakened and finds itself possessing its former essential attributes as to heating qualities.

Limited Production.—The production of charcoal is restricted to moderate limits, owing to the abundance and cheapness of coal and its greater commercial value.

How Made.—In the preparation of charcoal, billets of wood are built in a heap and covered with earth or sand. The heap is fired at openings left near the bottom of the pile, and the gases escape at the top. For making fine charcoal, such as that of willow, which is used in the manufacture of gunpowder, the wood is burned in iron cylinders, or rather retorts, in which a process of destructive distillation removes the volatile hydrocarbons and other undesirable elements.

How Used.—Charcoal is used in the arts as a fuel, a polishing powder, a defecator and a decolorizer of solutions and water and an absorbent of gases and aqueous vapors, a non-conducting packing in ice-houses, safes and refrigerators, and is an ingredient in gunpowder and fireworks; it is also used in the galvanic battery and in the generation of electric light.

Comparative Summary of the Charcoal Industry.

	1880	1890	1900
Number of establishments...	175	....	183
Capital invested............	$457,484	....	$811,225
Wage-earners................	1,401	....	1,786
Wages paid..................	$390,697	....	$431,381
Value of products	$975,540	....	$1,133,658

Chemical Fire Extinguishers.

Recognition. — Chemical fire-extinguishers, while of admitted merit, are not meeting with that general recognition their efficiency deserves. In the commercial sense they are passing through an experimental stage, but their constant demonstrations of high efficiency in subduing conflagrations are drawing more attention to them. In 1880 there were three establishments engaged in their manufacture, employing 119 workmen and producing engines worth $204,693; while the number of establishments building them in 1890 increased to 9, the output declined. In 1900, 17 establishments were equipped for their building, but the product reached only $217,693.

Chemicals, Heavy, Manufacture of.

Remarkable Growth.—The chemical industry has within twenty-five years assumed phenomenal proportions. Perhaps none other has attracted as much technical skill in which the principles and laws underlying this science are being studied and developed. Chemistry within a few years has been mainly responsible for the building up of some of the greatest industries in the United States. Comparatively speaking, it is a new and uncultivated field. Vast as have been the developments made within the past century, greater developments are on the eve of accomplishment.

Leading Chemical Products.—To attempt to cover this great subject within a limit of pages would necessarily be futile. Among the leading products with which chemical methods have to do are acids, sodas, potashes, alums, coal-tar products, cyanides, wood distillation, fertilizers, bleaching materials, electro-chemicals, dye stuffs, tanning materials, paints and varnishes, explosives, plastics, essential oils, liquefied gases, as well as chemicals in general.

Extent of Industry.—There are 1,740 establishments in the United States, most of them of large proportions, producing chemicals of every conceivable variety, which our summary accounts for in detail. Of the former, 459 are concerned in the manufacture of a general line of chemicals, 77 plants are producing dye stuffs, 70 essential oils, 97 explosives, 422 fertilizers, 615 paints and varnishes, etc. These plants employ 46,766 workmen and pay out in round figures $22,000,000 per annum in wages. The value of the products is $202,582,396.

Sulphuric Acid.—The manufacture of sulphuric acid is one of the largest chemical industries. Its manufacture was first largely entered upon during the third decade of the past century. These plants were followed by the erection of brimstone plants, pyrites plants and many others, and with the development of various newly-discovered processes the production of chemicals of almost endless kinds laid the foundation for the present enormous industry.

Other Acids Manufactured.—Among other acids which occupy the attention of chemical manufacturers to a great degree are nitric, mixed acids, muriatic, boric, acetic, lactic, citric, tartaric, tannic and gallic. Soda products are among the most important of chemical products. This is especially illustrated in the extraordinary increase during the past decade, in which the output was increased from 330,000,000 pounds in round figures to 1,280,000,000 pounds. The varieties produced were soda ash, sal soda, bicarbonate of soda and caustic soda, the value of which increased from $5,000,000 in 1890 to $10,000,000 in 1900.

Alums.—The production of alum increased almost fivefold from 1880 to 1900, or from 40,000,000 pounds to 180,000,000 pounds, and the value increased from $800,000 in round figures to $2,450,000. The kinds of alum used are potash, ammonia, birch, concentrated and carbide. Pennsylvania leads as a rich chemical manufacturing State, the products of its alum factories alone being 75 per cent. of the entire production of the United States.

Coal Tar Products.—An impetus was given to tar distilling by the discovery of aniline colors by Perkins in 1856. Benzol, which is the raw material of manufacture, was exclusively derived from coal tar. The value of coal tar products, according to the census of 1900 was $1,421,720.

Calcium Carbide.—The commercial production of calcium carbide began in the United States in 1894. It is used in generating acetylene gas, the reaction taking place when it is brought in contact with water at the ordinary temperature. It may be produced wherever a jet of water is available, as the energy stored in it is in a compact form and this energy may be readily made available again by generating the acetylene and burning it. Calcium carbide is looked upon as a material by means of which the energy of the water fall which is now going to waste may be made useful to man.

Carborundum.—Carborundum is now made under a patent granted February 28, 1883, and is made by heating a mixture of 34.2 per cent. of coke, 54.2 per cent. sand, 9.9 per cent. sawdust, and 17 per cent. of common salt in an electric furnace.

Carbon Disulphide.—Carbon disulphide is extensively used as a solvent and extracting agent. It dissolves sulphur, phosphorus, iodine, rubber, camphor, wax, tar, resin, and nearly all oils and fats. It is a germicide and insecticide and is largely used by transportation and storage companies, as well as by farmers, for exterminating mice, rats, prairie dogs and gophers.

Wood Distillation.—The industry of wood distillation has recently become a very important one. It produces wood alcohol, acetic acid, acetate of lime, pyroligneous acid and charcoal. Eighty-nine establishments are engaged in this industry, of which eighty-four produce regularly wood-distilling stuffs, such as crude alcohol, acetate of lime and charcoal. Pennsylvania leads in this industry with fifty-eight establishments producing two-thirds of the entire supply of the United States.

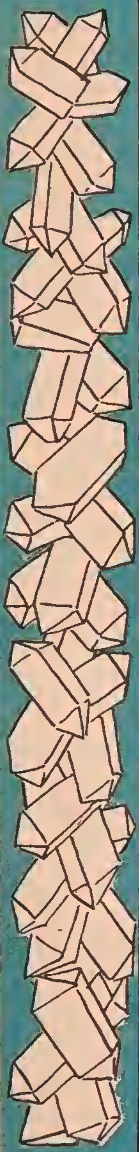
Chemical Substances Produced by the Aid of Electricity.—There are fourteen establishments in the United States producing chemical substances by electricity, with a capitalization of $9,173,060, whose production in 1900 amounted to $2,045,535. Most of these plants are located in New York. The Solvay ammonium process is the most important in this branch of the industry.

Liquid Air.—Liquid air is a mixture of approximately 21 per cent. oxygen, 78 per cent. nitrogen by volume with $\frac{94}{100}$ of 1 per cent. of argon, about $\frac{4}{100}$ of 1 per cent. of carbon dioxide and variable quantities of water, vapor ammonia and other

THE CHEMICAL INDUSTRY.

	NO. OF ESTABLISHMTS.	WAGE EARNERS	WAGES PAID	VALUE OF PRODUCT.
CHEMICALS	459	19,054	$9,401,467.	$62,676,730

· THE CHEMICAL ELEMENTS ·



NAME	SYMBOL	ATOMIC WEIGHT	NAME	SYMBOL	ATOMIC WEIGHT	NAME	SYMBOL	ATOMIC WEIGHT
ALUMINIUM.	Al.	27.08	GOLD (Aurum)	Au	196.7	RUBIDIUM	Rb.	85.2
ANTIMONY (STRIBIUM)	Sb.	120.0	HYDROGEN	H	1.0	RUTHENIUM	Ru.	103.5
ARSENIC	As.	75.0	INDIUM	In	113.4	SAMARIUM	Sm.	150.2
BARIUM	Ba.	137.0	IODINE	I.	126.5	SCANDIUM	Sc.	44.0
BERYLLIUM	Be.	9.1	IRIDIUM	Ir.	192.5	SELENIUM	Se.	78.9
BISMUTH	Bi.	207.5	IRON (Ferrum)	Fe	55.9	SILICON	Si.	28.0
BORON	B.	10.9	LANTHANUM	La.	138.5	SILVER (Argentum	Ag.	107.7
BROMINE	Br.	79.8	LEAD (Plumbum)	Pb.	206.4	SODIUM (Natrium	Na.	23.0
CADMIUM.	Cd.	111.8	LITHIUM	Li.	7.0	STRONTIUM	Sr.	87.3
CÆSIUM	Cs.	132.6	MAGNESIUM.	Mg.	24.4	SULPHUR	S.	32.0
CALCIUM	Ca	40.0	MANGANESE	Mn.	54.8	TANTALUM	Ta	182.0
CARBON	C	11.97	MERCURY (Hydrargyrum	Hg.	199.8	TELLURIUM	Te.	125.2
CERIUM	Ce	141.5	MOLYBDENUM	Mo.	95.9	TERBIUM	Tr.	150.0
CHLORINE	Cl.	35.4	NICKEL	Ni	58.6	THALLIUM	Ti.	203.7
CHROMIUM	Cr.	52.5	NIOBIUM.	Nb.	94.2	THORIUM	Th.	232.0
COBALT.	Co.	59.1	NITROGEN	N.	14.0	THULIUM	Tu.	170.7
COLUMBIUM	Cb.	94.2	NORWEGIUM	Ng.	219.0	TIN (Stannum	Sn.	117.4
COPPER (CUPRUM)	Cu	63.3	OSMIUM	Os.	191.1	TITANIUM	Ti.	48.1
DAVYUM	Da.	154.0	OXYGEN	O.	15.96	TUNGSTAN (Wolfranium	W	183.6
DIDYMIUM	Di.	144.6	Palladium	Pa.	106.2	URANIUM	U	239.0
ERBIUM	Er.	165.9	PHOSPHORUS	P	31.0	VANADIUM	V	51.2
FLUORINE	F	19.0	PLATINUM	Pt.	194.3	WOLFRANIUM	W	183.6
GALLIUM	GA.	69.9	POTASSIUM (Kalium)	K	39.0	YTTERBIUM	Yb.	173.2
GERMANIUM	Ge.	72.3	RADIUM	Ra	225	YTTRIUM	Y.	89.0
GLUCINUM	Gl.	9.1	RHODIUM	Rh	104.1	ZINC	Zn.	64.9
						ZIRCONIUM	Zr.	90.4

OIL INDUSTRIES-OFFICIAL.

	NO. OF ESTABLISHMTS.	WAGE EARNERS	WAGES PAID DOLLARS	VALUE OF PRODUCTS DOLLARS
Oil, Castor	3	49	29,068	395,400
Oil, Cottonseed & Cake.	369	11,007	3,143,459	58,726,632
Oil, Essential.	70	199	59,100	850,093
Oil, Lard.	7	78	42,205	1,221,841
Oil, Linseed.	48	1,328	693,311	27,184,331
Oil, not elsewhere specified	194	1,386	700,050	17,183,799
Oil, Resin.	8	90	53,596	738,680
Oleomargarine.	24	1,084	534,444	12,499,812.

bodies. Several methods are used to obtain liquefaction.

Comparative Summary of the Chemical Industry, General Line.

	1880	1890	1900
Number of establishments . .	595	563	459
Capital invested............	$28,983,458	$55,032,452	$89,091,430
Number of workers	9,724	15,038	19,054
Wages paid.................	$4,222,663	$7,308,411	$9,401,467
Value of products..........	$38,644,458	$59,352,548	$62,676,730

Cigar Box Industry.

Extent of Industry.—It costs over $6,000,000 annually at present to supply the cigar-making industry with boxes. Their manufacture constitutes an important industry in which sycamore is largely used as being the cheapest and most serviceable wood available for this particular purpose. Mills manufacturing cigar boxes have specially designed machinery for this purpose. The wood is cut just sufficiently thick to answer the intended purpose and paper binding is frequently added to give the box sufficient strength for transportation and handling.

Statistics.—While the consumption of cigars is steadily increasing the use of cigars in boxes has of of late been declining somewhat, owing to changing trade conditions and sharp competition among manufacturers, as a comparison of the following figures show:

Comparative Summary of the Cigar Box Industry.

	1880	1890	1900
Number of establishments...	221	291	315
Capital invested............	$1,023,777	$3,374,451	$3,288,272
Wage-workers...............	2,365	5,125	4,609
Wages paid..................	$748,657	$1,802,666	$1,439,599
Value of products...........	$2,903,485	$7,091,948	$5,856,915

Clay Products.

Clay.—There is probably no kind of clay products, from the commonest brick to the finest art china, that is not produced or found in the United States. In the manufacture of clay a vast industry has been built up for the production of the various products called for by the multiplying requirements of modern life.

Clay Products.—Among the products into which clay is converted may be enumerated as follows: Brick, tile and terra-cotta, including common brick, pressed brick, fancy colored front brick, vitrified brick and blocks, electrical conduits, sewer-pipe, drainage, flue linings, stove linings, furnace fittings, gas retorts, glass melting pots, fire brick, roofing, floor and encaustic tile, hollow brick, chimney tops, architectural terra-cotta, and a variety of higher grades for household purposes.

Pottery Products.—The ordinary pottery products are stoneware, yellow and Rockingham ware, cream-colored ware, white granite ware, semi-vitreous porcelain ware, chinaware, art pottery and some other products. The increased output is largely due to the use of labor-saving machinery.

Composition.—Clay is composed of hydrous silicate of aluminum usually with a mechanical admixture of sand, iron oxides and other substances. Clay has been divided by some writers into thirteen varieties, as follows: Slate clay, adhesive slate, polishing slate, lithomarge, fuller's earth, tripoli, bole, lemnian earth, cimolite, mountain meal, black chalk, pipe clay and potters' clay. The color of clay depends upon the iron it contains. Fire clay is refractory, according to the greater percentage of alumina it contains in proportion to alkalies. Clay possesses the property of absorbing ammonia and organic matter from liquid sewage.

Pottery History.—Pottery has been known from the most ancient times, and like many other arts, it originated with the Chinese, who are seldom given proper credit for the many arts which they originated and developed to as probably as high a state of perfection as exists to-day. The art was carried from China to India, and thence successively to Arabia, Spain, Italy and Holland. The earthenware of the Greeks and Romans was unglazed, but they covered their pottery with wax, tallow and bitumin, and other material which we know little of, to render it impervious to water, wine, etc. The Romans used molds for ornamenting clay vessels and for making figures of idols or limbs, plants, etc., for votive offerings. The potteries of London were started by Holland potters in 1640.

Tile.—Tiles, both flat and curved, were in great demand in Roman architecture. Roofs were covered with the flat and curved tiles alternating. Tiles 2 feet square, with a foot at each angle, were used so that an air space between them and the wall would prevent the absorption of water. Roofing tiles are of two sorts—plain and pantiles —the former flat, $\frac{5}{8}$-inch thick, 10½ inches long and 6¼ inches wide. They are hung upon lath by two oaken pins; pantiles were first used in Flanders. Crown, ridge, hip and valley tiles are semi-cylindrical or segments of cylinders. Siding tiles are used as a substitute in some cases for weather boarding. They are sometimes called "mathematical" tiles, and are variously formed, having curved or crenated edges and variously ornamented, either raised or encaustic.

Dutch Tiles.—Dutch tiles for chimneys are made of whitish earth, glazed and painted with various figures. Drain tiles are usually made in the form of an arch and laid upon flat tiles called soles. Paving tiles are usually square and thicker than those used for roofing. Galvanized iron tiles are used in France and are shaped like pantiles, so that each laps upon its neighbor in the course, and each course laps upon the one beneath it.

Terra-Cotta.—Terra-cotta is a compound of pure clay, fine grained, color of sand or calcined flints and pulverized, molded, and dried in the air and baked in a kiln. It is especially used for architectural decorations, figures, vases, etc. Terra-cotta articles are found in ancient Mexican sites and indicate very early historic origin, and probably prehistoric origin.

China.—China is so called because of its having been made first in China, where it was made before the Christian era. No account of its manufacture has been brought down to modern times, but the processes for its production were certainly developed to a very high degree of perfection. The fine variety of pottery now known as porcelain is of Portuguese origin.

Improvements in Pottery.—Remarkable improvements have been made in pottery manufacture, which are most observable at the great manufacturing centers, Trenton, N. J., and Liverpool, Ohio. The better grades of work now produced are equal to the best in the world, although the bulk of production is made up of those lines most called for by domestic needs.

The processes of applying heat in such a manner as to convert suitable raw material into form for use have been much improved by numerous inventions, in which the fundamental requirements are practically the same.

Porcelain stands between glass and pottery, being formed of two substances, fusible and infusible, the latter enabling it to withstand the heat necessary to vitrify the former, and producing a semi-translucency. The infusible material is alumina, called kaolin; the fusible substance is feldspar—both Chinese terms. There are two kinds, hard and soft; the hard has more alumina and less silex and lime.

Porcelain Clay.—The clays for porcelain should contain more sand and of greater fineness, which does not retain water with too much tenacity. Silicious earths found in a stony state abound in flint; the purest are found in crystals, for which fixed alkalies, vegetable or mineral, are solvents. Flint and bone are first calcined before using. The glaze used consists of an easily melted mixture of certain earths which when fused together produce a crystalline or vitreous mass. This, after cooling, is very finely ground and suspended in a sufficient quantity of water. The rough ware is dipped, in some potteries, in this fluid, when the glazing material is deposited uniformly on every part of its surface. After drying, each article is thoroughly baked or fired in the violent heat of the porcelain furnace. It is usual to decorate porcelain by painting, for which purpose enamels or pastes, colored by metallic oxides, are used, so easily of fusion as to run in a heat less intense than that in which the glazing of the ware melts.

A porous fawn is made of 40 parts argellaceous clay, 4 of blue clay and 2 flint; jasper, of 10 parts chalk, 10 blue clay, 5 bones, 2 flint and 1¼ blue calx. All these materials should be ground together.

Colored Clays.—These clays are used for painting various articles, as well as bottles, in the mosaic style. A black clay is made of 4 parts black Egyptian clay, 1 part white clay and 1 part blue clay. A blue clay is made of 30 parts white clay and 1 part calx; green, of 12 parts white clay, 1 nickel, ¼ blue clay.

Enamels and Fluxes.—Enamels are thoroughly dried after being ground, then mixed with turpentine and used with a pencil; after this they are fused again and vitrified by fire. The lusters will bear the highest temperature of enameling heat.

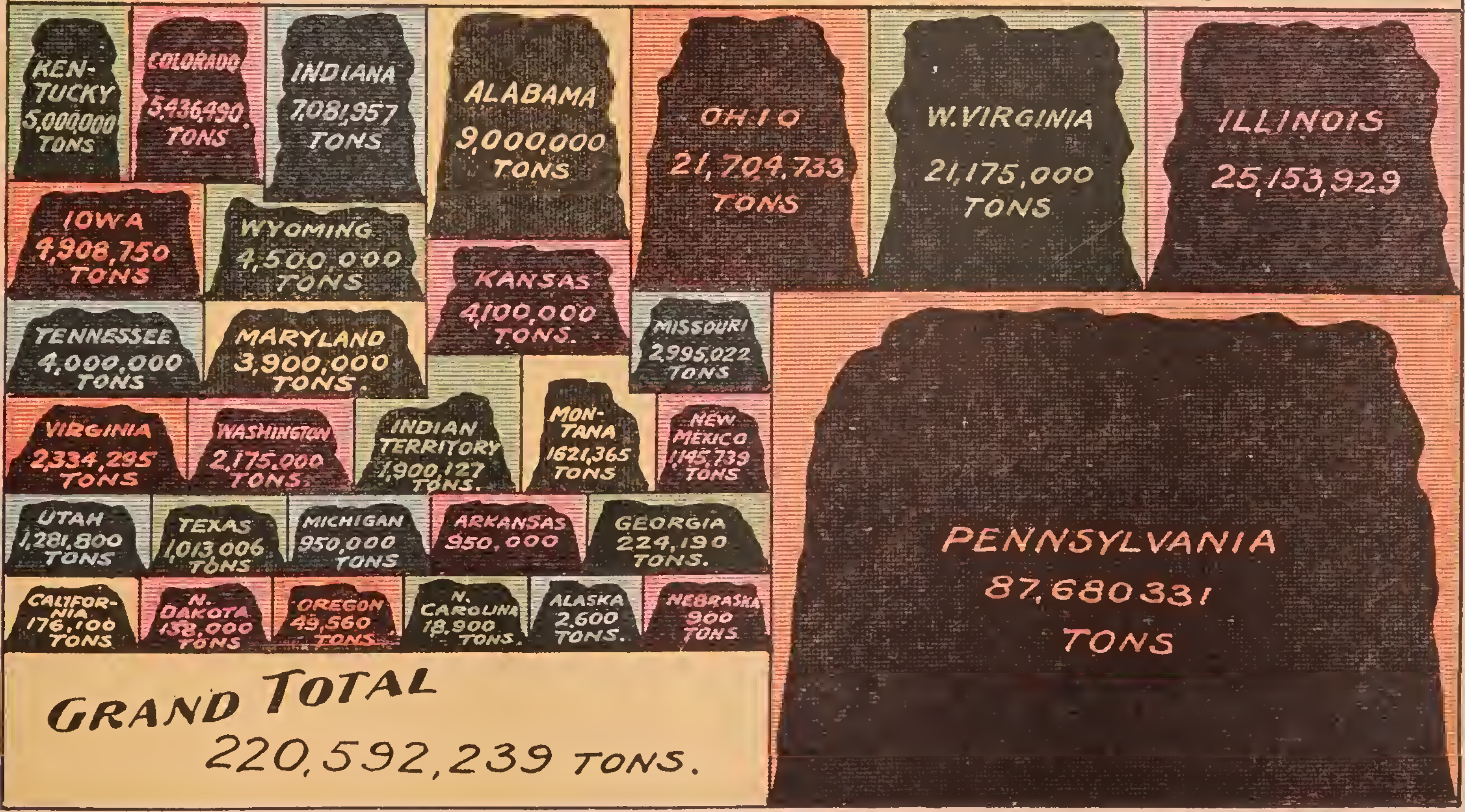
Black Enamel.—Copper black depends upon a proper temperature of the heat being applied; if there is the least degree of overfiring, the color is destroyed and becomes a dirty green. The other blacks, called umber blacks, will stand any degree of heat required in an enameling kill or muffle.

Gold Flux.—This consists of 11 parts borax, 5½ litharge and 1 silver oxide. The materials should be ground very fine, particularly the flint, and mixed well together. Gold bronze is made of 2½ parts burnish gold, 2 copper oxide 1 quicksilver and ¼ gold flux.

POTTERY, MASONRY, BRICK AND STONE-WORK INDUSTRY.

	Nº OF ESTABLISHMTS	WAGE EARNERS	WAGES PAID	VALUE OF PRODUCTS.
			DOLLARS	DOLLARS.
BRICK AND TILE	5423	61,979	21,883,333	51,270,476
CHINA, DECORATING	169	360	148,004	693,800
CRUCIBLES	11	671	250,654	2,607,308
EMERY WHEELS	34	546	303,091	1,381,675
GRINDSTONES	25	1,167	407,153	1,088,909
HONES & WHETSTONES	18	189	72,879	196,323
MANTELS, SLATE & MARBLE	36	449	291,050	1,153,540
MARBLE & STONE WORK	6,070	54,370	28,663,241	85,101,591
MASONRY, BRICK & STONE	8,333	93,568	53,152,258	203,593,634
MILLSTONES	3	37	20,957	75,922
PAVING & PAVING MATERIALS	1,729	34,090	14,570,408	46,447,719
PIPES, TOBACCO	98	1,585	737,647	2,471,908
POTTERYY, TERRA COTTA	1,000	43,714	17,691,737	44,263,386
ROOFING & MATERIALS	2,162	15,362	6,996,810	29,916,592

PRODUCTION OF COAL FOR ONE YEAR FOR U.S.



Green Enamels.—Blue-green is made of 42 parts redlead, 15 flint, 12 borax and 2¾ blue vitriol calcined. There are various platinum lusters, purple enamels, red enamels, carnelian reds, rose colors, steel luster, white enamels and various glazes, all made by separate processes developed by study, skill, experiment and observation.

Comparative Summary of the Pottery Industry.

	1880	1890	1900
Number of establishments..	752	707	1,000
Capital invested...........	$7,366,323	$26,127,104	$65,951,885
Wage-earners...............	10,221	18,980	43,714
Wages paid.................	$3,600,727	$8,869,032	$17,691,737
Value of products..........	$8,977,333	$22,057,090	$44,263,386

Clothing Makers and Clothing.

History.—It is within a comparatively brief period that the manufacture of apparel, especially clothing, has been entered upon on a large scale. To-day the manufacture of clothing has become a most important industry. The stimulus was imparted some thirty years ago in the larger Eastern cities, especially in New York City, by the application of machinery to operations theretofore conducted by hand. The invention of the sewing machine was the first decided stimulus, though a prior one was the manufacture of cotton, woolen and worsted goods by the wonderful mechanical appliances and processes which began to appear as far back as 1830. The perfection of the power loom opened the way to the clothing manufacturer.

English Jealousy.—For a long time the jealousy of English manufacturers prevented any practical knowledge from reaching American loom makers. For many years the worsted manufacturer was restricted to goods intended for women's wear. About 1860, French and English manufacturers began to apply the process to men's wear, and soon after the clothing manufacturer appeared. It was E. R. Mudge, of Boston, who offered the first home-made worsteds for sale. Light-weight suitings for men began to be made in 1869, and soon after mills sprang into existence. The use of worsteds reduced the output of woolens. Woolen goods were first made in 1643 in Massachusetts villages. Spinning jennies came in 1814. William Crompton introduced the power loom in 1840.

American Ingenuity.—American ingenuity and enterprise soon overcame all obstacles, and invention followed invention until all excepting the finer grades of woolens and worsteds were made at home. With such a foundation it is not to be wondered at that clothing manufacture soon assumed immense proportions. For a long time ready-made clothing was not looked upon with favor, but under the deft and skillful fingers of workmen, objections were overcome, and the "merchant tailor" gradually found his control slipping away. Manufacturers learned how to produce clothing to fit almost any figure with sufficient exactness to make their work salable. With sewing machines and "cutters" that cut many pieces at once, and with a wise division of labor, the manufacturer of clothing soon built up an industry of vast and abiding proportions.

The use of cutters which cut with mathematical exactness many thicknesses of cloth, the use of hand and power sewing machines of specially adapted construction, the organization of labor into special departments, each doing a particular part of work, and the use of machinery speeded up to the limits of human ability to do work—all have enabled manufacturers to build up an industry the annual output of which is now in excess of $400,000,000 a year.

The following Comparative Summary shows the extent of the Men's Clothing Industry for three decades.

	1880	1890	1900
Number of establishments...	6,166	18,658	28,014
Capital invested............	$79,861,696	$182,552,938	$173,034,543
Wage-earners................	160,813	217,270	191,043
Wages paid..................	$45,940,353	$87,714,314	$79,434,032
Value of products...........	$209,548,460	$378,022,815	$415,256,391

Clothing, Men's.

Old-Time Methods.—The manufacture of clothing as a separate industry is of recent origin, and is the outcome of the conditions in which we live. Formerly—and even now, in certain parts of the world—clothing was made in the household, when all operations were laboriously and most patiently conducted, from the raising of the plants producing the fibre to the securing of the products from which the raw material was procured. These materials were subjected to all the necessary primary operations and dyed and finished after a manner which reflected remarkable ingenuity of the early peoples. The old-time spinning-wheels are even now not altogether discarded. History has shown in all ages the crude devices and described the methods employed for the conduct of the tedious operations which produced clothing.

New Conditions.—The dawn of the industrial age introduced new conditions and requirements. It created the tailor's handicraft, and for centuries the tailor was a much-esteemed member of the earlier handicrafts which began to be differentiated during the Dark Ages.

Establishment of the Industry.—It was in the United States, and within fifty years, that the manufacture of men's clothing became an established industry. It was during the decade of 1860-1870 that the industry received its greatest incentive, during which time the increase in manufactured clothing doubled. Fifty years ago a multitude of small shops had sprung into existence, whose average annual output was $11,000. At present the average annual output of a clothing factory is $50,000, the newer and the larger factories greatly exceeding these figures.

Opening for Female Labor.—One feature of this industry is the field it opened to female labor. Fifty years ago, 4,800 women were engaged in clothing factories, and 5,739 men.

Substitution of Women in Factories.—There is in progress a gradual substitution of women for men, with a consequent slight decrease in the price of labor. This is particularly noticeable during the past decade, when the average number of women employed in factories where men's and women's clothing were made was 75,621. The number of men employed, in 1900, in both lines, was 67,786.

Growth of the Industry.—One stimulus to the growth of the industry was found in the system of cutting cloth for clothing, which was adopted by all manufacturing plants. Methods of taking measurements were improved, and clothing manufacturers soon adjusted their processes to all possible requirements of demand. Thus the use of "ready-made" clothing, which at one time was regarded by the community as an evidence of poverty and lack of good taste on the part of the user, came to be differently regarded. Most of the clothing now worn is "shop made," and compares favorably with the "custom made," both as to material, style and satisfaction.

Machinery.—The employment of numerous labor-saving devices, including cutting devices and the use of sewing machines specially constructed for clothing-factory work, coupled with the skill of operators and supplemented by the willingness of householders and tenement occupants to contribute their time and service for moderate recompense, all united to impart to the clothing manufacturing industry an impulse which has placed it among the more important industries of the United States.

Distribution of the Industry.—The distribution of the men's clothing industry is interesting. Of the 5,731 establishments reported in 1900, 266 were in the New England States, 3,258 in the Middle States, three-fourths of which were in the State of New York; 310 in the Southern States, 1,790 in the Central States, 7 in the Western States and 100 in the Pacific Coast States.

First Maker of Ready-Made Clothing.—George Opdyke, subsequently mayor of New York, was the first to engage in the manufacture of ready-made clothing on a large scale in the United States. Soon after, the wholesale clothing houses of that city began to manufacture better grades of ready-made clothing. As stated elsewhere, the sewing machine created new conditions. The English, Scotch and American tailors, who controlled the industry before 1850, were followed by Irish, and next by German tailors, which latter class introduced the subdivision of labor.

The Task System.—The introduction of the "task system" was another epochal event, which tended to drive out the all-round tailor. Instead of one tailor making a coat all by hand, five or more persons, aided by machines, were employed. "Team" work at "task" prices soon became the rule. The "team" consisted of three men—an operator, a baster and a finisher—each with his particular part to do. This, under bitter competition, resulted in "long hours" and the "sweating" system.

The Contracting System.—One of the evils of the contracting system is the creation of the subcontractor, who does no work and employs no labor, but sublets to other contractors. This system has flourished under competitive conditions, and seems to be the avenue through which gradual progress is being made to better conditions. There is a growing sentiment, however, against it which in time may gather sufficient force to make a departure from it possible.

The Sweating System.—This evil grew out of the fact that the unskilled labor of hordes of immigrants was found available at home. This industry has become a haven of refuge for many of these people, to whom even low wages was and is a welcome escape from less enviable conditions in their European homes. The objection to home work is that the work is done probably under unsanitary conditions. The low rate of wages, it is

CLOTH AND CLOTHING INDUSTRIES ~ OFFICIAL.

	NO. OF ESTABLISHM'TS	WAGE EARNERS	WAGES PAID DOLLARS	VALUE OF PRODUCT DOLLARS
Cloth. Sponging and Refining.	46	534	268,191	560,000
Clothing. Horse.	26	575	176,687	1,305,164
Clothing. Mens.	28,014	191,043	79,434,932	415,256,391
Clothing. Women's. Dressmaking	14,479	95,595	14,352,453	48,356,034
Clothing. Women's (Factory Product.	2,701.	83,739	32,568,101	159,339,539.

COTTON, LINEN, WOOLEN AND CARPET INDUSTRIES ~ OFFICIAL.

	Nº OF ESTABLISHM'TS	WAGE EARNERS	WAGES PAID DOLLARS	VALUE OF PRODUCT. DOLLARS
COTTON COMPRESSING.	111	2,742	738,288	2,629,590
COTTON GINNING.	11 369	14,135	1,930,039	14,748,270
COTTON GOODS.	1,055	302,861	86,689,752	339,200,320
COTTON WASTE	26	1,116	336,827	5,880,024
CARPETS AND RUGS.	133	28,411	11,121,383	48,192,351
CARPET RAG.	1,014	1,504	492,656	1,993,756
CARPETS WOOD.	31	608	362,112	1,056,702
WOOLEN GOODS.	1,035	68,893	24,757,000	118,430,158
WORSTED GOODS	186	57,008	20,092,738	120,314,344
WOOL HATS.	24	2,108	937,855	3,591,940
WOOL SCOURING	25	720	338,606	889,809
UPHOLSTERING MATERIALS	270	5,098	1,715,073	10,048,164
FELT GOODS.	36	2,688	1,024,835	6,461,691
DYEING & CLEANING.	1,810	5,424	2,271,066	7,567,358
DYEING & FINISHING TEXTILES	298	29,776	12,726,316	44,693,331
LINEN GOODS.	18	3,283	1,036,839	4,368,159.

MANUFACTURES OF WOOLENS AND WORSTEDS IN UNITED STATES.

·FROM CENSUS REPORTS·

WOOLEN GOODS··			WORSTED GOODS		
	1900	1890		1900	·1890
Nº of Establishments	1,035	1,311	No. of Establishments	186	143
Capital	$124,386,262	$130,989,940	Capital	$132,168,110	$68,085,116
Salaried Officials Clerks etc.	2,246	2436	Salaried Officials, clerks etc	1,369	2615
Salaries	$2,934,048	$2,339,737	Salaries	$2,342,218	2$935,217
Wage Earners.	68,893	76,915	Wage Earners	57,008	42,978
Total Wages.	$24,757,006	$26,139,194	Total Wages	$20,092,738	$14,944,966
Miscellaneous Expenses	$7,268,634	$8,402,623	Miscellaneous Expenses	$6,767,611	$4,917,760
Cost of Materials used	$71,011,956	$82,270,335	Cost of Materials used	$77,075,222	$50,706,769
Value of Products	$118,430,158	$133,577,977	Value of Products	$120,314,344	$79,194,652
No. of Spindles	1,906,581	1,815,380	Nº of Spindles	1,371,026	755,080
			Nº of Looms	26,372	19,095
No. of Looms	34,881	39,118	Nº of Combing Machines.	1,194	673

said, is also affected by the competition of some persons in comparatively comfortable circumstances who are not under necessity to engage in it to earn "pin money." The result is that the rate of compensation is reduced to a very low level.

The Boston or Factory System.—This system prevails in many cities, and under it the subdivision of labor has been extended to minute detail. Instead of five people working under this "task" system, as many as a hundred can be placed on the work of a coat. By this restriction of work to minute parts, great skill and speed are acquired, with resulting economy in cost and minimized wages. The worker under this system becomes practically dependent, and weekly wages take the place of task or piece price.

Machines for Cutting Cloth.—Machines for cutting cloth were introduced in 1870 by which many thicknesses of cloth were cut at once. Long knives were at first introduced, but these later were replaced with circular disks like buzz saws. A sponging machine enables two persons in less than two hours to sponge cloth for 100 coats, as against about 12 hours by the hand method. Material for that number of vests can be sponged in 20 minutes, as against three hours and twenty minutes by hand methods. Statistics patiently gathered in every line of the clothing industry demonstrate the fact of the remarkable expansion of production by the application of machinery, including sewing machines, to almost every department of work. The amount of work turned out in all the numerous branches of clothing manufacture, from the cutting of the material to the making of buttonholes and the sewing on of buttons, has been increased from five to twentyfold.

Sewing of Seams.—Work on coats which required 1,000 hours by hand is now done in 65 hours; trouser work 423 hours reduced to 65 hours, and the same for vests. Time on a given number of button holes is reduced from 3 hours and 20 minutes to 18 minutes. Time required for sewing buttons on trousers is reduced to one-ninth as against hand labor. These reductions of time have been effected in all branches of factory work.

Comparative Summary of Men's Clothing Industry.

	1880	1890	1900
Number of establishments ..	6,166	18,658	28,014
Capital invested	$79,861,696	$182,522,938	$173,034,543
Wage-earners	160,813	217,270	191,043
Wages paid	$45,940,353	$87,714,314	$79,434,832
Value of products	$209,548.460	$378,022,815	$115,256,391

Clothing, Women's.

Women's Clothing as an Industry.—The manufacture of women's clothing as an industry of any importance did not start until about the time of the Civil War. Previous to that time only outer garments, such as cloaks and mantillas, were made in small shops. In the next two following decades most of the work done was still confined to women's ready-made clothing, such as cloaks; but it soon after assumed the dimensions of an organized industry. Shortly after 1880 an additional branch of the industry was developed, viz., the making of ladies' suits. This was followed by the manufacturing of goods known under the collective name of "lingerie." For a long time only the cheaper grades of women's wear were made, but gradually it was found that expensive materials could be profitably worked up into ready-made garments and readily sold to patrons of taste.

Expensive Clothing Made.—At the present time garments varying in price from the cheapest to the most expensive suits are bought ready-made, and with a little adaptation fit snugly to the form and are finished in whatever style and "make-up" the changing fashions may decree. All grades of women's wear are now produced in factories.

Machinery.—The introduction of machinery and improved methods have wrought great changes in this industry, but hand labor still prevails to a considerable degree. Machines are used for cutting cloth, and machinery is variously applied in the larger factories in the handling of large quantities of material. The working of button-holes, for instance, is greatly simplified, and the labor has been reduced to one-fifth the time formerly occupied on a given amount of work.

Methods Employed.—The methods employed in the manufacture of women's clothing very greatly reduce the labor and cost, as well as deprive women of the incentive or occasion to do their own sewing at home. The division of labor is carried out to a very high degree. The "task" system has never been applied to cloak making, however. The work is mostly "piece work," but a fair percentage of workers work by the week.

In the larger cities much of the work is done by Polish and Bohemian women, who, with little experience, are found to be competent workers. This has resulted in the displacing of men by women to a large degree, as well as in a readjustment of wages conformably to the requirements of this class of labor.

Women's Suits.—The making of women's suits has increased to a large extent during the past decade, but the garments are made at different shops. For instance, waists are made in one place and skirts in another. Shirt-waist workers generally work in sets, eight persons being required to produce a waist as made in shirt factories. As many as seven machine operators make different parts. One sews on the buttons, one makes button-holes and one irons the waist after the various other parts have been completed.

Electric Power Used.—In almost all shirt-waist and underwear factories electric power is now used. In 1900 the industry was carried on in twenty-three States.

Features of Decade of 1890-1900.—In contrast with the manufacture of men's clothing, this branch of the industry showed a large increase in the number of wage-earners and wages paid. The increase from 1890 to 1900 was from 39,149 to 83,739, and the amount of wages paid was over double. The development of the industry during the decade was of such a nature that men were substituted for women in the manufacture of certain of the better grades of clothing, such as cloaks and ladies' suits, while the greatest number of women were added in the factories for shirt-waists and underwear.

Comparative Summary of the Women's Clothing Industry.

	1880	1890	1900
Number of establishments..	562	1,224	2,701
Capital invested	$8,207,273	$21,259,528	$48,431,544
Wage-earners	25,192	39,149	83,739
Wages paid..................	$6,661,005	$15,428,272	$32,586,101
Value of products	$32,004,794	$68,164,019	$159,339,539

Coal Mines and Mining.

Coal Deposits.—Modern civilization owes more to coal than any other known material. It is the mother of steam and the brother of capital. It is the agency through and by which the world has, within a century, made greater strides than were made during the entire Christian era. It opened up possibilities which the imagination cannot measure and has made activities possible that have transformed the world into a hive of industry. It is the basis of the industries which have marshaled the people of the civilized countries into armies more mighty than the armies of the world's great conquerors. Formerly supposed to exist within restricted limits, it is today discovered scattered throughout the world in vast deposits, whose limits are not susceptible of even approximate estimate. A mere enumeration of these deposits with loose approximations of their extent and probable endurance in face of the economic wants of the world would possess no special interest.

Influence of Coal.—The coal-mining industry is the mother of a number of closely and remotely related industries which, in their entirety, go to constitute an interest vast in extent and of the greatest importance to the future industrial progress of the United States and the world. In fact, when rightly viewed, coal is the factor which is effecting transformation in the world's habits, methods, standards, capacities and progress. While it has accomplished much, very much more remains to be accomplished, which even the instinctive prophetic mind of Americans does not more than faintly recognize. It has as one of its grand consequences the brotherhood of man, through the instrumentality of industry aided by commerce.

Coal and the Industries.—What Great Britain has achieved as the "workshop of the world" can be achieved in lesser degree by other countries and, in fact, is being measurably achieved. Its coal deposits are the basis of its vast industrial system and its mighty shipping industry. By its coal, it has attracted the attention of the world to the importance of industry and has stimulated the lethargic energies of millions into activity. In the United States, coal has led to the establishment of industries and an industrial system which has placed it as a producer and dispenser of products in the forefront among the nations. The coal miner and the farmer are the twin giants who have enabled the United States to become a mighty power for the spread of civilization.

First Findings of Coal.—The earliest record of the existence of coal in the United States was made by Father Henepin in 1698, when he found a deposit on the Illinois river near the present city of Ottawa. The first coal mining was done at Richmond, Va., about 1750, and in 1775 it was used in forges to manufacture arms and ammunition for the American army. In 1779, shipments were made to Philadelphia, New York and Boston. A small mine was opened in Rhode Island in 1760.

Its First Industrial Uses.—In 1768 two blacksmiths who had used coal in England discovered it in the Wyoming Valley, Pennsylvania, and used it in their forges; eight years later, in 1776, coal was carried down the Susquehanna to Carlisle Barracks, Pa. It was not until 1808 that Jesse Fell, of Wilkesbarre, demonstrated its utility in manufacturing. Philip Ginter, a hunter, found "stone" coal in 1791, and in the following year Robert Morris organized the Lehigh Coal Company to market it, but people had not learned how to burn it. Subsequently, the right method of burning was discovered and it rapidly came into use.

Extent of the Anthracite Deposit.—The anthracite area is some 500 square miles in extent, generally divided into fields known as the Schuylkill, Lehigh and Wyoming regions. The present anthracite region is but the remnant, by denudation, of what once covered 2,000 square miles and which possibly contained upward of 100,000,000,000 tons. The amount of coal available at the beginning of the historic period is estimated at something under 30,000,000,000 tons, of which possibly 1,200,000,000 tons approximately have been marketed. The thickness of the various beds varies widely. The Mammoth vein varies from 14 feet or less in the Scranton district to 20 feet in the Wyoming district and 20 to 40 feet in the Lower Schuylkill. Its average thickness is estimated at 25 feet.

The Bituminous Area.—The great bituminous coal measures are divided into four and sometimes five fields. The greater, the Appalachian, occupies an area of 60,000 square miles. It extends from Pennsylvania to Alabama and most of it occupies a plateau extending in Tennessee 2,000 feet above the sea. The whole field is divided into upper coal measures, barren measures and lower coal measures.

The Illinois Basin covers about 47,000 square miles; the Michigan Basin, 6,700; Missouri Basin, 90,000 square miles.

The Pittsburg bed ranges from 6 to 12 feet and is found in Western Pennsylvania counties. The area, as actually covered in Pennsylvania, is about 9,000 square miles, but the upper productive measures extend over only a fractional portion of this area. The barren measures hide large areas of the lower productive areas. The Cumberland coal fields extend 30 miles and are 4½ miles wide. The main seam, the "Big Seam," averages 12 feet, in some places 14 feet, and averages 5,000 to 6,000 tons per acre. In Virginia there are several detached coal fields containing workable beds.

West Virginia Coal Fields.—The West Virginia coal fields are extremely valuable; out of 54 counties, but 6 are without coal. That State has latterly attracted miners in large numbers and within two or three years over one hundred producing companies have begun operation. Its beds are known as the Potomac Basin, the New River and Kanawha fields. One of the products of this State is cannel coal.

North Carolina has its Dan river field, 40 miles long and 4 to 7 miles wide. The coal fields of Ohio cover 10,000 square miles. Their length is 180 miles by 80 miles wide. In a portion of this field the coal-bearing rocks are from 1,400 to 1,500 feet thick and the aggregate thickness of workable beds 40 to 45 feet.

Southern Coal Fields.—Eastern Kentucky coal fields cover 9,000 square miles and Western Kentucky 4,000 square miles. The coal measures of Tennessee cover 51,000 square miles, where there are nine seams, of which six are over 3 feet thick. Alabama has 5,500 square miles of coal in three separate basins. The largest is the Warrior, the second the Cahaba and the third the Coosa. The coal measures of Alabama contain 10 to 12 beds from 2 feet upward. The Georgia coal measures are unimportant.

Western Measures.—The coal measures of Indiana are 650 feet in thickness, and one zone is 150 miles long with an average thickness of 3 miles; the other contains three workable beds from 4 to 10 feet thick. The Illinois coal field covers 36,800 miles, has 10 seams in a vertical thickness of 600 feet, six of which range from 2½ to 6 feet. In the southern section of the State the seams are 6 to 7 feet thick and the coal is generally reached by shafts 200 to 400 feet deep.

The Iowa coal basin covers nearly one-half of the State. The lower measure is 200 feet and contains two beds, which in places are 5 feet thick. Missouri has 8,406 square miles of coal, but many of the seams are unworkable. Coal occurs in most Western States, but in veins too thin to be worked. Valuable coal is being found in unexpected localities all over the West, and the effect on industrial development and manufacturing progress is quite apparent. Vast and valuable beds have been located in Alaska.

Lignites.—The "lignites" are destined in time to form an important part in industrial economy. Most of them contain 12 to 15 per cent. of water and are superior to most European lignites. The beds are of great size and are remarkably free from impurities. In Wyoming, twenty-two workable beds have been developed. In some localities workable beds underlie fire-clay, or sandstone, and vary in thickness from 3 to 100 feet.

Mining and Handling.—The methods of mining and handling coal have been greatly improved during the past few years. The expansion of manufacturing, especially the iron and steel industry, and the extension of the railway system have been two sources of demand, which have created an enormous market for coal, the production of which is over 300,000,000 tons per annum. The science of mining has been greatly developed, the cost of production decreased, irrespective of labor, and the distribution of the product has been facilitated by transportation facilities by rail and water.

Mechanical Coal Cutters.—The present methods of mining coal are different in the degree to which mechanism for cutting and handling and transporting has been applied by means of steam and electricity mainly. The introduction of mechanical coal cutters has been quite general throughout the mining regions of the interior, by means of which a number of holes are bored at once and rapidly, to facilitate the work. These machines are compact, strong and serviceable; are easily and cheaply operated and greatly reduce the cost of labor and increase the output of the mine materially. They have been successively improved until they are now available for thin seams of coal and are adapted to the ordinary powers used to actuate machinery. The application of electricity in mines has of late reached significant proportioned, and through this power still greater economies are in sight as well as increased production of mines.

Hand Work.—The mining of coal is, however, largely a matter of hard and patient manual labor, with pick and shovel, aided largely by the use of powder for blasting, by which coal is dislodged from its seams, and is then broken up and loaded into mine cars which reach the facings over temporary tracks laid. As the miner makes progress he insures his personal safety by placing lumber props on each side of the "room" leading from the "entry," which are placed sufficiently close to each other to prevent the sagging of the roof. In soft coal mines the usual method is to "under cut" into the coal in order to deprive the superimposed coal of its supports, after which the work of breaking down is conducted more easily. Much of, in fact, most of, this work, especially in low veins, is performed in a sitting or leaning posture which taxes the muscular energy more than ordinary upright posture.

Ventilation.—Methods of mine ventilation have been the subject of patient and scientific study for generations, the objective point being to provide a sufficient supply of pure air and to prevent the accumulation of gases and fire-damp. The mechanical appliances for this purpose represent a high degree of skill and efficiency, and accidents to life when they occur are generally discovered to be due to carelessness or forgetfulness of the miners themselves. Legislation makes abundant provision for the safety of life in mines, and these requirements are generally complied with in every detail. The condition of the mines is carefully observed day by day and hour by hour, and the mechanical arrangements for ventilation and for the handling of fuel are supervised by experts thoroughly skilled in their profession.

Mine Hauling.—The system of transporting coal from the mouth of the mines to market has been revolutionized, especially along the line of quick handling, by large and specially provided cars and quick transit. This is especially true as regards coke, for the transportation of which exceptionally large cars are built, and which, by means of special construction of bottoms, can be emptied of their contents almost instantly into provided receptacles.

The Miners.—Whether it is because the miners prosecute their lonely work far under ground, where there are no distracting surroundings or what not, they constitute, as a class, a body of men of superior intelligence and conservatism. They are, as a class, careful readers and thinkers and in point of sobriety and upright conduct are deserving of credit. While strikes among them are frequent and often bitter, and while violence is manifested in their resistance to employers, there is, after all, an intelligence and uprightness which especially characterizes them among all workmen. Even in the anthracite regions where vast numbers had their birth in foreign lands, and who have not enjoyed the advantages of education or of the recognition that is due to manhood, the miners exhibit a degree of enlightenment which is deserving of favorable comment.

Production of Coal in the United States.

	Anthracite.	Bituminous.	Total.
1870	13,973,460	15,369.120	29,342,580
1880	25,572,160	38,250,670	63,822,830
1890	41,489,958	99,377,073	140,866,931
1900	54,255,540	220,592,239	274,847,779 (Short tons.)

Coke.—The coke industry is naturally associated with that of coal. The special value of coke in metallurgical operations consists in the comparative absence of deleterious substances and in the rapidity of oxidation of impurities because of its cellular construction. There is a comparative freedom from ash and less sulphur or phosphorus. Only some bituminous coals produce coke. The largest deposit of coke-producing coal is in Southwestern Pennsylvania and is known as the "Connellsville." This region covers about 70 square miles and produces over 250,000 tons of coke per week, which fills 10,000 cars. There are two forms of ovens used, the beehive (from its shape), and the Belgian oven, in which the resultant gases are used to heat the ovens so that the yield is correspondingly increased. A hard, resonant coke with large cells and silvery lustre is most approved for metallurgical purposes. Coking coal is found in other localities and the coking of coal is extending, but the chief center of the industry must for a long time remain in Southwestern Pennsylvania.

The production of coke in the United States increased from 3,338,300 net tons in 1880 to 11,508,021 tons in 1890, and 20,533,348 tons in 1900. Its chief use is in blast furnaces and foundries, and in minor ways it is used in many manufacturing establishments.

Coffee and Spice Industry.

When First Known.—Coffee was not known to the Greeks or Romans, but had been used from time immemorial in Abyssinia and Ethiopia. In Arabia its use was known in the fifteenth century, and it was used throughout Asia in the sixteenth century. It is a native of Abyssinia, Arabia and parts of Africa, and was brought to the West Indies in 1720, from whence its cultivation extended into Central and South America.

First Coffee Houses.—Constantinople was the first European capital in which coffee houses were instituted, which was in the year 1554; the first coffee house in England was opened in 1650 at Oxford; they were suppressed by Charles II where Protestant treason and coffee came out of the same pot, but in 1675 were allowed to be reopened.

Production.—The annual production a decade ago was estimated at 40,000 tons in Africa, 400,000 tons in Brazil, 60,000 tons in Ceylon, 100,000 tons in Java, 50,000 tons in Manila. But these figures have since been greatly exceeded, especially in Brazil. Taken in moderation coffee is regarded as one of the most wholesome beverages known, assisting digestion and exhilarating the spirits. Chicory and other substances are often used as substitutes or adulterations, and usually only give pure coffee a greater depth of color.

Roasting and Grinding.—It was the household practice for many decades to purchase coffee green and roast it in the home and grind it for daily use. This method is still preferable for many reasons, but the roasting of coffee calls for a degree of skill and judgment which is usually not possessed by those whose duty it is to prepare it. Consequently, the roasting of coffee was undertaken by manufacturers who built special machinery to roast large quantities properly and at a very small cost. By taking proper care, the roasting and grinding is effectually done and in a manner to obtain the greatest use of the grain. The pulverizing of coffee followed the rough grinding and much coffee is now sold in this way. The aroma is retained by careful roasting, grinding and sealing. The machinery for roasting and grinding is complicated and ingenious and does its work with regularity and economy.

Spice Mills.—Spices are made from vegetable substances possessing aromatic and pungent properties, such as cinnamon, cloves, ginger, pepper, etc., and are largely obtained from torrid countries, much of the supply coming from Asiatic sources. Specially constructed spice mills receive these products and grind and crush them in a manner somewhat analogous to the processes contained in a well-established flour mill, but a much greater degree of care, knowledge and adaptation of machinery to the peculiar qualities of the grain are necessary.

Coffee Substitutes.—The substitutes for coffee are rye coffee, German coffee, rice coffee, currant, gooseberry, holly, Egyptian coffee made from chickpeas; rosetta coffee, made from fenugreek seeds; Corsican coffee, made from the seeds of kneeholly; sassafras coffee, made from the sassafras tree, which is recommended for skin diseases; raspings coffee, made from the crusts of loaves of bread; beechmast coffee, made from beechmast or nuts, which is very wholesome; acorn coffee, made from acorns deprived of their shells; beet root coffee, made from beet roots; bean coffee, made from horsebeans, roasted with a little honey or sugar; and almond coffee, made with the almonds mixed with wheat or rye.

Statistics.—The magnitude of the roasting and grinding industry in coffee and spices is seen in the fact that there are 458 establishments in the United States employing 6,387 workmen, producing goods worth $69,527,108. The capital invested amounts to $28,436,897. Wages paid, $2,486,759.

Collar and Cuff Manufacture.

The First Collar.—A collar made on a paper pattern suggested to Ebenezer Brown, of Troy, New York, in 1825,, the idea of making collars in commercial quantities, which he proceeded to do. At first the collars were made by the female members of his household, the linen cut to shape with scissors, half stitched and starched, and ironed on the kitchen table. So the increasing demand for what was known as Brown's store collars encouraged him to engage the services of the wives and daughters of his neighbors. The material was cut in his store from wooden patterns and then taken home to be made, washed, starched and ironed. These collars soon became widely known; they were tied around the neck of the wearer with a tape-string, and were known as "string collars." They were made of two-ply heavy linen, stiffened with starch and supported by cloth stocks buckled at the back of the neck.

Linen Collars and Shirt Bosoms.—The manufacture of linen collars and shirt bosoms was soon after entered upon as a separate business. In the year 1845 the manufacture of cuffs and shirts was begun as a natural outgrowth of the collar and cuff industry. When the sewing machine appeared it was utilized for the greater extension of the industry. The advantages of machine over hand-work were soon seen and appreciated, and other manufacturers who had in the meantime started up began to manufacture them. The next step was the application of steam power, which greatly reduced the cost of production and resulted in a proportionate decrease in the price to consumers, with an increase in demand.

Varieties Appeared.—Endless varieties of the standing and turn-down collars soon appeared in process of manufacture. After the examination as to the strength and color of the linen and muslin, a desired number of thicknesses was placed upon the table and weighted down to keep in position. The back and front of the collar were cut together, the interlinings being cut by a second operation. In the straight standing collar the facing is usually of cambric muslin, excepting in the case of an all-linen collar, which must conform to the shape of the front of the collar. The interlining in a four-ply collar is cut in one piece and doubled over.

Putting Together.—The separate parts are cut out, the facings are sent to the stampers, after which the constituent parts are arranged by the pasters, and after this sent to the turner. The pieces are stitched at the top and sides by the "turners," the reversing or turning of the collar, which requires considerable skill, was done by home workers, although later on machinery was devised to do this work.

The Turn-Down Collar.—The turn-down collar is composed of two parts—namely, the top and the band. The band is made of three pieces—back, front and interlining. The part comprising the front and top and back are fitted together, overseamed and run. The banding requires considerable skill. Interlining and back of band are stitched to one side of the top, and the front is stitched to the other side; the band is then turned to its proper shape. The buttonholes are next made, and the collar is then complete.

Laundry Apparatus.—Many of the larger manufacturers operate laundries in connection with their factories. Wonderful improvements have been made in machinery and laundry apparatus, and both starching and ironing are now extensively done by machinery. Records of the Patent Office show that there have been issued 8,762 patents in connection with the laundry industry.

There were manufactured, in 1900, 10,086,045 dozens of collars and cuffs, 856,868 dozens shirts and 81,948 dozens shirtwaists. The bulk of the production is in the State of New York.

Comparative Statement of the Industry in 1900.

Number of establishments	57
Capital invested	$10,216,317
Wage-earners	17,115
Wages paid	$5,658,969
Value of products	$15,769,132

Comb Manufacture.

Early Use.—Combs have a great variety of uses and subserve a great many utilities; they have been known in some form or other in all ages. Combs are spoken of in the ancient books; fish bones were sometimes ground into a form to answer the purpose. Various devices have been used by peoples in all ages as combs, some of them quite artistic and representing a wonderful degree of workmanship in their finish. A comb may be simply defined as a toothed instrument for straightening, cleansing and adjusting hair, flax, wool and any material of like nature.

Materials Used.—Various preparations are used in the manufacture of combs, celluloid probably being one of the most common, though silver, tortoise shell, bone, metal, ivory, etc., are largely used.

Extent of the Industry.—The extent of the industry in 1900 is shown in its 34 establishments, employing1,399 workmen, with an invested capital of $832,791, producing products having a wholesale value of $1,976,129. The output of combs measured by values has doubled within twenty years, in which the finer varieties are shown increasing preference in the trade.

Confectioners and Confectionery.

Production.—The production of confectionery in the State of New York alone exceeds the value of its production of iron and steel, enormous as it is. Confections represent a mighty industry, which in that State in the last decade increased in value of product from $13,000,000 to $19,000,000. The increase in Massachusetts in that decade was 32.6 per cent. In Pennsylvania, Ohio and other States a remarkable increase in production is shown. The total production in the United States in 1903 exceeded $90,000,000 in value.

Cheap Sugar.—Seeking for the reasons, they are found in the increasing supply of cheap sugar and the remarkable expansion of machinery and manufacturing facilities. Inventive talent has been remarkably busy during the past few years in the devising and production of mechanical appliances for the more economic production of confectionery in enormous quantities. Great central plants have been erected, equipped with costly machinery and manned with a peculiarly adept class of mechanics, whose skill in the handling of raw material to the diversified finished products has won for them a reputation enjoyed by but few craftsmen.

Expansion of Manufacturing.—The remarkable expansion of the confectionery industry is also in large measure due to the commercial methods adopted of late years in methodically and persistently soliciting business, also to the remarkable increase in the establishment of attractive retail stores, especially adapted to the handling of confectionery. Another creditable cause is that almost all American confectionery is of a very high degree of purity and mostly free from adulterants.

Capacity and Equipment.—To those not familiar with the interior of a modern confectionery plant, it would be a matter of surprise to observe the extraordinary innovations in manufacturing methods which have been adopted in recent years. Not only has the size of the equipment been increased, but a long list of new and novel appliances has been introduced to facilitate the production of "sweets" from the raw product to the finished confection. Mechanical engineering skill has been employed, as well as the highest designing and inventive skill, to manufacture appliances which reduce hand labor to a minimum and manual handling as well.

Variety of Preparations.—Another cause of increased demand is to be found in the endless variety of preparations in which confectionery is offered to the public, as well as to the most toothsome combinations of accessories from chocolates and vanillas and a score or two of "supplies" which the good taste, skill and art of the workmen embody in their products. Medical science is of late more definitely recognizing the hygienic value of confections, and the nutritive properties of sugar are better known and appreciated than formerly.

Manufacturing Facilities.—The establishment of large plants in the greater cities, where every possible mechanical device is adopted for economic production, has resulted in the production of confectionery of great variety; from these centers confections are distributed throughout the United States with dispatch. The old-time pots and pans and primitive methods have been superseded with the later gigantic facilities. Temptation is offered in every form in well-arranged and well-kept stores, where pure goods are neatly packed by deft fingers in attractive boxes. While more or less adulteration prevails in cheaper grades, and which is revealed in prices at which such confectionery is offered, the general tendency is to purity. The industry is expanding rapidly under the stimulus of cheap sugar and the abundance of supplies which enter into the composition of confectionery.

Comparative Summary of the Confectionery Industry.

	1880	1890	1900
Number of establishments	1,450	2.901	4,297
Capital invested	$8,486,874	$23,326,799	$35,155,361
Wage-earners	9,801	21,724	33,583
Wages paid	$3,242,852	$7,783,007	$10,867,687
Value of products	$25,637,033	$55,997,101	$81,290,543

Cooperage.

Old-Time Coopers.—The cooper has been an important craftsman for two or three thousand years. Just how the early coopers did their work is not told us, but it is evident from many paintings and old drawings in some of the older museums that the art of cooperage was sufficiently well understood in the early ages to furnish receptacles for valuable liquids which it was desired to preserve for use.

London Coopers.—The first distinctive record of cooperage as a class is given in the records of London when a guild was incorporated in 1501. Coopers were in those days defined as tight, wet, dry and white coopers, according to the purpose for which their work was intended. The tight coopers and wet coopers made casks for holding liquids; the dry coopers made casks for flour, rice, dried fruits, etc. The white cooper made butter casks, tubs, pails and churns.

Mechanism in Coopering.—There are 885 patents for various kinds of coopering in the United States, from the smallest vessel to the largest casks. Special machinery is now devised for the manufacture of the enormous casks which the commercial requirements of the present day call for, especially for the large casks used in California, where they are employed in wineries. A great deal of machinery has been invented in the production of barrel staves and barrel heads. Recent tub-crozing machines have been invented showing fine mechanical ability. A number of machines are in use for the making of fruit baskets.

Growth.—The industry is gradually increasing in extent and in the volume of its products. The extraordinary demand for barrels and casks in the malt and whiskey manufacturing industries have built up quite a number of extensive plants wherein barrels for beer and whiskey are manufactured.

Increasing Uses.—A score or two of industries are annually making increasing requisitions on the cooperage industry for the transportation and storing of materials, including salt, flour, sugar and molasses, lime and cement, fruit—especially apples—fish, and scores of commodities which cannot be conveniently handled or transported in other receptacles.

Woods Used.—Cooperage in recent years has placed its hands on many woods that a few years ago were not used at all or only used in a small way. Among these may be mentioned sweet gum, that grows on the bottom lands of the Mississippi Valley. It is now a high-priced wood, Europeans having taken it freely as "satin walnut." Some coopers alternate sweet gum staves with oak. Gum is always sawed, because "riving" is impossible, for lack of grain.

Coopers know that any kind of wood is liable to twist, but "lock grain" is rare in ash, oak, poplar, beech and linn. Black gum is always lock-grained. Willow, for a long time rejected by the cooper, is now extensively used for heading, but it is difficult to saw, because the bark hangs to the teeth and chokes the saw. The sawyers call this "saddle-bagging" the saw.

For a long time even red oak was rejected, but it is now in general demand for headings and staves. It is difficult to dry, and retains moisture tenaciously, which makes it hard to handle even when dry.

It is the custom to plane headings with the grain, and to feed each piece into the planer so that the cutters will not work against the grain. The sawed side of tough, soft wood, like soft maple, cottonwood and maple, is apt to show long "frazzles," sometimes called wool, and then the wood is hard to saw.

Broadening Requirements. — The systems and methods for preparing material for the cooper have been greatly improved in recent years, and the mechanical appliances in the cooperage plant have also been modified in the direction of a larger output per man. The development of the great chemical industry and the multiplication of dyeing plants and the increase in the tanning industry, as well as increasing capacity in many other industries which use the products of the cooper's plant, have united to sustain an enormous demand. The rapid growth of the industry has, however, been curtailed to some degree by the use of receptacles made of iron and steel in place of wood.

Comparative Summary of the Cooperage Industry.

	1880	1890	1900
Number of establishments..	3.898	2,652	2,146
Capital invested............	$12,178,726	$17,806,554	$22.568,873
Wage-earners..........	25,973	22,955	22,938
Wages paid..................	$8,922,603	$10,056,249	$9,200,303
Value of products...........	$33,714,770	$38,617,956	$40,576,462

Cordage and Twine Making.

Cordage in Early Times.—The first use of material which answered the purpose of twine as used at this day of which we have record is mentioned in Exodus, xxvi, 26, "Thou shalt make an hanging of blue and fine twine linen, wrought with needlework." Then was not only twine made in those early days, but linen and needles, and the people were evidently accustomed to their uses. Twine and cordage was one of the earliest essentials of life, and their use expanded apace when those conditions of society arose which we characterize under the term civilization. Cordage has, in all ages, played a very prominent part in developing commerce and trade, as is indicated by frequent references to its use in the old books and writings.

Twine Manufacture.—With the systematic development of agriculture, twine became an important article and gradually developed into a considerable industry. At the present time it is one of the leading industries in the West, the product being largely used to bind grain for its convenient handling in the earlier stages of its passage from the soil to the mill. It is produced to a greater or less degree in prisons as a means of furnishing available employment to criminals.

Materials Used.—Various materials are used in the production of twine and cordage, among them cotton, flax fibre, hemp and jute. Raw cotton, yarn and waste are used in cotton twine and cordage. The qualities of flax fibre used are known as rough, tow and line, supplies of which are received from Europe and Canada, in addition to the home supply.

Hemp.—Hemp is distinguished as Manila, Sisal, New Zealand and Russian, Italian and American. The yarns used are made of jute, silk and worsted. A great supply comes from Manila, the quantity imported in 1900 being 123,241,820 pounds, out of a total supply of 418,416,811 pounds, costing $26,632,006; and from Sisal, the quantity for that year being 146,352,853 pounds. In 1900, 26,540 bales of cotton were used to produce 13,022,755 pounds of twine and cordage product. The value of all twine and cordage manufactured in the United States that year was $37,849,651, in which the item of binder twine alone amounted to $14,185,581, and was mainly consumed for agricultural purposes.

Rope.—Rope is made of cotton, Manila, Sisal, jute, gummy bagging and jute burlap. The value of rope produced in 1900 was $14,666,829. The superior quality and longer life of American rope is creating a demand for it in many parts of the world. In China rope is made of grass, hemp, jute, palm and bamboo.

Comparative Summary of Cordage and Twine Industry.

	1880	1890	1900
Number of establishments ..	165	150	105
Capital invested............	$7.140.475	$23,351.833	$29,275.470
Wage-earners...............	5,435	12,385	13,114
Wages paid..................	$1,588,676	$3.976.232	$4,113,112
Value of products..........	$12,492,171	$33,312,559	$37,849,651

Cork Making.

Nature of Cork.—Cork is an extremely important wood in the industries and domestic economies, and is obtained from the outer layer of bark of what is known as the cork tree. It is a very elastic tissue, consisting of thin wall and nearly cubical cells. The cork does not peel off the tree readily and often contains long clefts. It is readily compressible, extremely porous, and by reason thereof is adaptable to the closing of bottles, casks and vessels containing liquids. It is also used to more or less extent in many of the industries.

Machines for Cutting.—Machines are made for the express purpose of cleanly cutting cork and tapering for different uses. The knife of this machine cuts a perfect arc, the machine drops the cork into one receptacle and the shavings into another, and the hone instantly sharpens the knife for further work. Another machine for pressing corks consists of a lever-press with jaws, which presses the cork into the desired shape. Machines are made for driving corks into bottles, which they do with remarkable rapidity to the great saving of time and trouble.

Equipment.—A portion of the equipment of the cork factory consists of a press in which the cork, previously wetted, is rendered elastic to enable it more readily to enter the neck of the bottle. In one form the cork is placed between the serrated surfaces of the concave and the eccentric cam and is pressed to a lesser or greater extent by the partial rotation of the cam.

Where Grown.—The cork tree grows in Spain, and is most abundant in Catalonia and Valencia. Some cork wood is found in New South Wales as well as in the West Indies.

Extent of Industry.—The industry has become quite an important one with the growth of the bottling industry, and also that branch of industry which manufactures larger receptacles for the holding of various liquors. There are 62 cork-cutting establishments in the United States, employing 2,340 workmen, producing corks worth $4,392,364. The capital invested in these establishments amounts to $2,683,683.

Corset Making.

Universal Acceptance.—The word corset is of Italian origin, though an article of feminine apparel, known as the corsettus, was worn by Roman women. It is evident from the evidence afforded by excavations of ancient ruins and burial-places, as well as from some early paintings, that some article of like purpose was in quite general use among women, although it lacked those especial features which modern skill and the use of whalebone and steel and superior textile material has latterly given this important and comfortable article of dress.

Nature and Fashion.—The instincts of nature, as well as of fashion, dictate the use of such supporting and conforming device, and it is not to be wondered at that in all ages and in all countries the corset, in some form or other, has been used by the female sex. Physiological reasons also lend their consent to its use.

Stimulus Given by Sewing Machines.—The industry of corset making received an impetus with the coming of the sewing machine and the advent of mechanical appliances. Whalebone appears to be less used in most of the cheaper grades of corsets, having been driven out, probably, by the cheaper steel that has been adapted for such uses. The supply of whalebone is steadily decreasing, but the serviceability of the corset does not suffer in consequence.

Comparative Summary of Corset Making.

	1880	1890	1900
Number of establishments...	113	205	216
Capital invested............	$1,611,695	$6,640,056	$7,481,048
Wage-earners	8,802	10,928	12,729
Wages paid................	$1,745,969	$3,509,039	$3,791,509
Value of products	$6,494,705	$12,401,575	$14,878,116

Cotton Ginning and Compressing.

The Giant Among Crops.—The cotton crop of the United States is the greatest single crop produced in the world, and the greatest in importance as measured by its commercial value and in the utilities which it subserves. It is the basis of vast industrial activities, and furnishes employment to a greater number of people directly and indirectly, and requires a greater volume of capital in the various ramifications of its transformation into use, than any other natural or manufactured product. Cotton is the basis of the clothing of the people of the world, and it enters into various materials that are used in the industries.

Its cultivation and its preparation from the gin to the loom, and its use in a great variety of ways with other textiles, furnish employment for labor, skill, taste and ingenuity beyond any other product of the soil.

It is comparatively a new product, and a very recent gift to mankind. The United States is blessed in being the most favored spot on the globe for its cultivation, and to American inventors and mechanics belongs much of the credit for providing the appliances and devising the methods whereby this most valuable fibre is converted into material for use in clothing and other articles of use.

Thus far no mechanical devices have been invented by which the cotton can be gathered from the stalk in the field, though numerous efforts have been made to that end. The picking is perforce done by hand, and the product is first subjected to human invention in the cotton gin, where the first separation takes place.

Ginning.—In the development of the cotton gin quite a number of valuable improvements have been introduced. In the earlier processes only the long staple fibre was secured, leaving the cotton seed covered with a short fibre which, with the seed, was regarded as a waste product. To reclaim this short fibre and secure the seed in condition for use have been the main endeavors of inventors during the past twenty years. Within this period 114 patented processes have been worked out, resulting in the proper delinter of today, and which reclaims both the fibre and the seed in condition for use, the former as wadding, the latter as a valuable cattle food.

Pneumatic Feed Devices.—Another progressive step of great practical importance has been the introduction of pneumatic feed devices for gins whereby the cotton can be fed at once from the wagon to a series of gins. There are ninety-one different ways of doing this, but those in practical use are very few.

The production of a machine capable of decorticating the stems of ramie or China grass has been long the objective point of a good many inventors, but as yet none have reached commercial success.

Compression of Cotton.—Cotton growers have been for a long time anxiously looking for mechanical appliances which would enable them to get away from the old square bottom bale, and they have been rewarded for their patience by a cylindrical press which presses the cotton much closer, makes it substantially fire-proof and more convenient for handling. Cotton presses were invented, in 1847, to roll cotton into bales; another was invented, in 1848, of roller press form, and subsequent inventions for rolling cotton appeared from time to time. It was not, however, until 1891, that the idea of forming the cotton into a sheet or bat first suggested itself. A machine was invented which rolled the cotton into cylindrical form, each layer being subjected to pressure as it is wound on the spindle. This improvement was followed by several others, one being a press comprising an upright frame carrying an upper stationary and a lower movable roll, and a positively driven core located between them. Later improvements appeared in which the core is driven from the rolls, and these were the first commercially successful cylindrical presses introduced.

Endless Belt Improvement.—Subsequent improvements appeared in which the distinctive feature was a weighted endless belt within the loop or bight of which the bale is formed, layer upon layer.

Trying New Methods.—A still further improvement appeared in 1895 in which a cylindrical cotton bale was formed of a bat wound spirally, layer upon layer, the bale being of great and substantially uniform density throughout. Efforts are now being made to form rectangular bales of super-imposed layers, each being subjected as laid to heavy pressure. The folded bat press has been recently improved in several particulars. In each of these improvements the cotton is taken in a bat from the gin compressor between rolls and led to the baling chamber, where it is folded back and forth and kept under pressure until a rectangular bale of sufficient size is formed.

The Volute Type.—Another type of press is the cylindrical or volute type, but these have to be stopped at intervals to remove the bale and start a new bale. This objection has been partially overcome.

Continuous Press.—A form of press has met with considerable favor in which the cotton, instead of being wound in a volute, is formed into a helix. The bat of cotton is fed under great pressure through a rotating head, which is pressed against the cotton already in the baling chamber. This press is continuous by constant feeding. It cuts the cotton off into bales of desired size as it emerges from the baling tube. These presses are adapted to use on the plantation and but one compression is required. The cotton is made into a highly condensed mass, equaling in density ordinary woods, so that it does not readily burn or smolder.

Comparative Summary of the Cotton Ginning Industry.

	1890	1900
Number of establishments	1,637	11,360
Capital invested	$3,221,987	$23,228,130
Wage-earners	6,920	14,135
Wages paid	$650,885	$1,930,039
Value of products	$2,367,450	$14,748,270

Enlargement of Area.—The improvements in ginning and compressing have made it possible to enlarge the cotton area and to economize the cost and labor to the great benefit of the industry.

Compressing.—The compression of cotton was represented in 1900 by 116 establishments, with an invested capital of $2,248,800, employing 2,742 wage workers.

Cotton-Seed Oil Making.

Development.—The development of the cotton-seed oil industry has been remarkably rapid. In 1860 it was treated as a waste; in 1870 it was used as a fertilizer; in 1880 it became a cattle food; in 1890 it became a table condiment, and in 1900 its use became general, and under disguised forms has obtained great popularity. Cotton oil was made as far back as 1837, but it attracted no attention.

Method of Preparation.—The cotton seed is brought from the field to the ginneries and there the fibre adhering to the seed is removed; the removal of the short fibre, known as linters, is the first process through which the seed passes to the oil mill. The clean seed consists of 2 per cent. linters, 48 per cent. hulls, and 50 per cent. meat. The seed, after passing through delinting machines, is run through hullers, which cut the seed and which drops into shakers, and then passes through beaters. A ton of seed yields 1,000 pounds of hulls. The feeding of hulls to cattle is being recognized more and more every year as a profitable use of this by-product, and cattle raisers find it a good flesh-producing feed.

Final Methods.—The separated meats pass from the shakers to the rolls, where they are crushed; then pass to cookers, where they are cooked to break up the oil cells. The cooked meats are then enclosed in camel's-hair mats placed in hydraulic presses and subjected to a pressure of from 2,000 to 4,000 pounds. The resultant crude oil is then pumped into settling tanks where it settles and the residue, after the expressing of the oil, is formed into hard cakes—oil cakes of commerce.

Cotton-Seed Meal. — All cotton-seed meal contains a larger percentage of nitrogen than any other food. It is the most concentrated, cheapest and most nutritious of foods for stock use. Mixing it with bran, middlings or hulls or other feeds, produces an ideal cattle food. There is obtained from a ton of seed approximately 275 pounds of crude oil.

Summer Yellow.—Crude cotton-seed oil, after its first process of refining, comes out in the shape of a clear, brilliant yellow oil, known as summer yellow, which is classified as choice, prime, off and scap oil.

Various Uses.—With the improved refining methods of the past few years there has been an increased demand for the product. It is used in the manufacture of lard, as a mixture for lard, oleo, stearine, refined cotton-seed oil and other products. It is also used in the manufacture of washing powders and is largely used by bakers as a substitute for olive oil. About 10 per cent. of the crude oil forms a by-product known as soap stock or foot, which is used in making wool-scouring soaps and cheap grades of laundry soaps. It is also used to produce glycerine, candle stock, olein and pitch.

Increase in Production.—The almost eightfold increase in the value of cotton-seed oil products in twenty years is an evidence of the rapidly expanding uses to which it is being put. Large quantities are exported, and portions of it, it is said, reappear as olive oil; but this substitution is not as general as is supposed. It is wholesome, and possesses high dietetic properties, and is making its way into a number of new channels of consumption.

Comparative View of the Cotton-Seed Oil and Cake Industry in the United States.

	1880	1890	1900
Number of establishments	45	119	369
Capital invested	$3,862,300	$12,808,990	$34,451,461
Wage-earners	3,319	5,906	11,007
Wages paid	$880,836	$1,493,780	$3,143.459
Value of products	$7,690,921	$19,335,947	$58,726,632

Cotton Spinning and Weaving.

First Cotton Mill.—The first cotton mill in the United States was built at Beverly, Massachusetts. In 1806 an old mill at Byfield, Mass., was equipped with English machinery, where the cotton-spinning industry was in a prosperous condition. The subject of cotton spinning very early attracted the attention of Americans, who were instinctively mechanical. They recognized the inconvenience of having to depend upon English factories for cotton goods, especially as the raw material was grown in their own country and transported, at great expense, three thousand miles or over to be manufactured into cloth.

Some Early Products. — As early as 1775 a spinning jenny of twenty-four threads was put in operation at Philadelphia, and in 1782, Samuel Wetherall, of that city, had established a successful business in making jeans, fustians and everlastings. In 1794 Samuel Slater, of Pawtucket, R. I., made the first cotton thread spun by water-power. In 1794 the first calico was printed at East Greenwich, R. I. When it was found that cotton goods could be manufactured, it stimulated inventive enterprise. Cotton duck was among the early cotton products. Between 1806 and 1815 fifty-seven cotton mills were erected in Massachusetts alone. In 1810, 611,481 yards of cotton goods of household manufacture were produced in Pennsylvania, of which over one-third was made in the city of Philadelphia. Early in the last century six large and successful cotton mills were built in Allegheny City, Pa., and supplied the Western trade via the Ohio river.

Fine Productions.—The use of cotton for decorative fabrics originated in Philadelphia, where it had early in the last century been brought to great perfection in turning out cotton tapestries and chenille curtains.

Cotton Spinning.—The cotton-spinning industry was greatly stimulated in the United States. The spinning wheel was a necessary piece of household furniture. It consisted of a wheel, band and spindle driven by the hand or foot. In 1850 the value of cotton goods produced was $61,869,184; in 1900, $339,200,320, or five and a half times greater output. To follow out the mechanical improvements in cotton manufacture during the half century would require a volume. The enthusiasm of hundreds of inventors has been applied to the task, and machine followed machine in rapid succession.

Foundation of the Industry.—The foundation of cotton manufacture was laid in the almost simultaneous invention of the steam engine and the spinning jenny. Hargreaves' spinning jenny was invented in 1764 and patented in 1770. Arkwright's water frame, the invention of drawing of rollers, was perfected in 1775; Crompton's steam engine was applied to cotton manufacture in

1785. In that year Cartwright's power loom completed the group of fundamental inventions.

Machines for Preparing Cotton.—An epochal event was the invention of machines for preparing cotton for manufacturing. The first of these machines was the scutching machine, introduced in Glasgow, Scotland, in 1800. John Crighton, of Manchester, in 1814, brought out the lap machine.

After a number of improvements came the carding machine, born out of the lap machine, which after numerous inventions became, in 1880, practically what it is to-day. The combing machine was first exhibited in 1851.

The number of cards in use in 1900 was 6,605 against 7,015 in 1890, a decrease of 410. The number of combing machines increased from 839 in 1890 to 1,415 in 1900.

The Loom.—The great epochal feature was the perfection of the loom to which inventors had directed their energies for years to secure greater speed. Francis Cabot Lowell, in 1814, improved, or rather reinvented, the power loom. Numerous inventions followed, aiming to reduce or do away with the time occupied in changing shuttles. This is now accomplished, not in changing the shuttle while the loom is in motion, but in giving the shuttle a fresh supply of weft without removing it from the loom. The success of the Northrop loom stimulated inventors to bring out new devices of the shuttle-changing variety.

Mercerization.—John Mercer, an Englishman, born in 1791, introduced, in 1845, what has since been known as "mercerization," which consists in treating vegetable fibre or cotton as yarn or of woven goods to the action of caustic soda dissolved in water and treating it subsequently with pure water and dilute sulphuric acid. This action produces a chemical and physical change in the fibre. Later experiments showed that if mercerizing is done under tension, the fibre becomes more translucent, the surface smoother and the goods acquire a greater lustre. This led to the reintroduction of the process now so generally used. The process has to be conducted with great care. When yarn is mercerized it is passed through the bath between rollers which prevent all contraction, then through the water bath and a weak solution of sulphuric acid under the same conditions.

Sheeting and Shirting.—The largest single item in cotton goods is sheetings and shirtings, made from coarse and medium yarns. Next in importance is print cloths not finer than No. 28 warp. Most of the other classes of goods are wholly or mostly woven from medium and coarse yarns. Not more than one-twentieth of the yarn spun for cotton goods is classed as fine, but there is a constant tendency toward finer spinning.

Water-Power.—Water-power has been partially supplanted by steam-power in cotton mills, the division in 1900 being 250,790 water horse-power and 527,186 steam-power. The possibilities of the electrical transmission of power obtained from water points to a reaction in favor of steam. Already over 20,000 electric horse-power is utilized and each year the amount of power so generated is increasing.

Steps of Progress.—The steps in the progress of cotton spinning before the advent of steam are marked by Hargreaves' spinning jenny, Arkwright's water frame, and Crompton's mule. All the older improvements in carding, drawing, roving and spinning were thrown open in 1785 with the advent of the power loom. Next came the scutching machine in 1800, the lap machine in 1824, which improved this method of opening and scutching; then the carding machine, which, with an improved revolving flat, made it the carding machine practically as it is to-day.

The Mule.—The mule was transformed as long back as 1835 into a purely automatic machine, which seemed almost endowed with human intelligence. Later improvements have been merely in details.

Frame Spinning.—This appliance was greatly improved by the ring and the traveler and resulted in the invention of the Rabbeth spindle, which produced yarn at about 10,000 turns a minute. Ring spinning became more economical than mule spinning.

The Shuttle.—At the speed at which modern looms are run the yarn in the shuttle is exhausted in about 8 minutes in the manufacture of shirting or print cloths. If the yarn is coarse and the speed the same, the shuttle needs to be changed still oftener. The fewer changes, the less the cost of labor, hence the increase in shuttle-changing devices. The best device to this end consists, not in changing the shuttle while the loom is in motion, but in giving the shuttle a fresh supply of weft without removing it from the loom.

The Northrop Loom.—The Northrop loom, which was first brought to the attention of manufacturers in 1895, met with rapid adoption because of two fundamental improvements, viz.: the filling-changing mechanisms and the warp-stopping devices. By the first, the stoppage on account of exhausted shuttles is wholly saved. By the second, the machine is stopped instantly upon the breaking of a single warp thread. In combination they add greatly to the productive capacity of the weaver who can operate 8 plain narrow looms. His time is chiefly occupied in replacing empty shuttles and in mending broken warp threads. A break of thread causes an imperfection and an empty shuttle means a stoppage of the loom. The filling-changing mechanism reduces the time needed to supply the looms with weft. The necessary devices have recently been applied to old mules. A weaver attending 8 looms and changing shuttles that contain yarn enough to supply the loom 8 minutes, has to make an average change of one a minute.

Number of Spindles.—There are 19,872,232 spindles in the United States, of which 19,050,952 are in cotton mills, 206,698 in hosiery and knit-goods mills, 95,356 in worsted mills, 59,460 in woolen and carpet mills, 102,366 in cordage and twine factories. In 1890 the total was 14,384,180 spindles. Of the 19,472,232 spindles in the United States in 1900, 13,171,373 were in New England, 1,721,347 in the Middle States, 4,354,034 in the Southern States, and 225,474 in the Western States.

Practical Perfection.—No radical improvement has been made during the past decade in spinning machinery of either kind, and inventors seem to have about reached the end of their tether. The mule is a perfect machine in the sense that it is automatic in every part. The quantity of yarn of any particular count which the ring spindle can make is directly proportional to the speed of the spindle itself. Ten thousand turns a minute come near to being the limit of the ring spindle under present conditions. Above that speed, the travelers are liable to fly off badly. On No. 28 warp yarn the speed is about 9,000 per minute. On coarse yarns, a spindle running 7,000 turns a minute is running relatively as fast as when it is going 10,000 turns a minute on fine yarns.

Consumption of Cotton Per Spindle.—The average consumption of cotton per spindle in 1880 was 70.43 pounds, in 1890, 78.79, and in 1900, 95.43 pounds.

The number of looms in the United States increased from 324,866 in 1890 to 450,682 in 1900. Of this increase, 22,453 looms were for the production of fancy weaves. Of the increase of 73,744 looms in the South, 66,130 were plain looms of all widths.

Mercerized Materials.—The uses to which mercerized materials may be put are various, but the process is successfully applied only to Egyptian and Sea Island cottons, which are silky. It is believed, however, that the fact that mercerized yarn loses something of its elasticity in gaining strength is against its general availability in the manufacture of hosiery and knit goods.

Production of Cotton Goods in the United States.

	1900		1890	
	Square Yds.	Value.	Square Yds.	Value.
Woven goods of the above were	4,509,616	$243,218,155	3,004,320,473	$193,874,275
Plain cloths for printing......	1,581,613,827	57,780,940	955,294,320	43,550,174
Brown and bleached.....	1,212,403,048	55,164,365	962,238,062	55,193,439
Ginghams.......	278,392,708	16,179,200	268,996,715	20,686,390
Ticks, denims, stripes........	171,800,853	16,446,633	167,121,426	16,987,546
Cottonades.....	26,323,947	2,791,431	....	....
Napped fabrics..	268,852,716	18,231,044	132,524,706	10,574,924
Fancy woven fabrics.......	237,841,603	21,066,310	127,373,179	12,545,929
Duck...........	129,234,076	14,263,008	55,192,538	8,664,395
Tapestries (pcs.).	10,131,538	4,123,600	1,559,436	2,070,239
Lace and lace curtains......	36,880,198	3,585,138	....	1,225,364

Cutlery and Edge Tools.

Early Cutlery.—The art of manufacturing cutlery is one of great antiquity. The use of edged tools was known in all historic times, though the edges did not possess the keenness of to-day because of the impossibility of removing the baser elements of the metal used. It is not known when the manufacture of cutlery began in England, but Sheffield has been known as a cutlery center for over five centuries.

Burnishing of Cutlery and Tools.—The burnishing of cutleryhas always been an art possessed by very few of the old-time workmen. In later times burnishers were improved and consisted of two kinds, steel and hard stone, either curved or straight, rounded or pointed, so as to suit projecting parts. Stone burnishers are made of blood stone, cut, and either rounded with the grindstone or rubbed so that they present at the bottom a very blunt edge and sometimes a rounded surface. The operation of burnishing is very simple. During the whole process of using it, the tool must be continually moistened with black soapsuds. In consequence of friction the burnisher soon loses its bite and slips over the surface of the article. In order to restore its action it is rubbed from time to time on leather. Two leathers are generally used, one of sole, the other of buff.

Burnishing Gold Leaf or Silver.—The burnishing of gold leaf or silver is done with burnishers made of dogs' teeth or agate, mounted in wooden or iron handles. The ordinary engraver's burnisher is a blade of steel made thin at one end and is used to give the last polish to such parts of copper and steel plate as may have been accidentally scratched or specked. The burnishing of cutlery is executed by hand or vice burnishers.

What Cutlery Covers.—The term cutlery is popularly applied to table knives, forks, scissors, shears, razors, etc. Cutlery is found in most ancient ruins. Forks were imported from Italy into England in the regin of James II and knives were first used about the close of the fifteenth century, each person who could afford them carrying them around to use.

Table Cutlery.—The manufacture of table cutlery began in Scarappa, Maine, in 1832; pocket knives were made in Connecticut in 1842. High wages attracted many good Sheffield workmen, and the industry expanded rapidly. All early cutlery was hand forged, but heavier cutlery, such as table and butcher knives, was machine forged. Hand and machine processes for making different kinds and grades of cutlery vary greatly. Pocket and penknives are made from rod steel; "mooding" is the rough shaping of the blade, then comes grinding. The various parts of cutlery are pressed or cut out with dies. The cutter assembles the parts and his work consists in drilling, filing, fitting, polishing and buffing the handles.

Material for Handles.—The material for handles embraces ivory, pearl, silver, gold, tortoise shell, stag horn, celluloid, rubber, California redwood, and ebony. Polishing is done on built-up wood wheels covered with leather, and over this is put a mixture of glue and emery. Buffing is done on wheels of leather, emery and glue; blade-finishing is done on emery wheels; glazing is done the same way and a superior finish is called crocus finish. Sharpening is done by hand on flat stones. Good razors are all hand forged from razor steel.

Etching.—Etching on cutlery requires a ground wax of equal parts of asphaltum, Burgundy pitch and beeswax melted together. It is applied with a dabber or ball of cotton covered with silk. The cutlery must be warmed so as to melt the wax; then smear it evenly, and when cold scratch the desired design or name and touch the parts with nitric acid made of 1 part water to 4 or 6 parts acid; the biting is done in a few minutes; then dip in hot water to wash off the acid, after which clean with benzine.

Cutlery may be hardened by using sal-ammoniac, 6 pounds; refined borax, 3 pounds; water, 4½ quarts, and red wine, 6 ounces.

Hardening Tools. — In the hardening of tools different kinds require different temperatures, which are indicated by shades of color. Pale straw is required for lancets, dark yellow for razors, dark straw for penknives, clay yellow for chisels and shears, very plain purple for plain tables knives, light purple for swords and watch springs, dark blue for fine saws, blue for large saws, pale blue for saws the teeth of which are set with pliers.

Tempering.—To obtain the proper temper it is customary to lay the metal on a lump of iron heated to a sufficiently strong heat. The clean, bright metal shows the degree of oxidation from the blue upwards, and the oxidation can be arrested at will.

Comparative Summary of the Cutlery and Edge Tool Industry.

	1880	1890	1900
Number of establishments..	429	474	309
Capital invested............	$9,859,885	$12,082,638	$16,532,383
Wage-earners................	10,519	8,708	12,069
Wages paid..................	$4,447,342	$4,200.933	$5,673,619
Value of products...........	$11,661,370	$12,110,614	$14,881,478

Dairy Productions.

The Dairy Industry.—The dairy industry of the United States has assumed colossal proportions during the past two or three decades. In the year 1900 there were 18,112,707 cows in the United States which were kept for milk, producing 7,728,583,350 gallons of milk, yielding 1,492,699,143 pounds of butter. The production of cheese on farms, in factories and in city dairy establishments amounted to 299,006,818 pounds, or practically 150,000 net tons. The production of condensed milk amounted to 186,921,787 pounds, or virtually 93,000 tons.

Value of Dairy Products.—The total value of butter made in the United States in the census year, at 18 cents a pound, amounted to $268,685,845; cheese, at 9 cents a pound, $26,910,614; condensed milk, $11,888,792; cream sold, $4,435,444; sundry products, $1,261,359; value of total milk consumed, $277,645,100; total aggregate of dairy products of the United States, $590,827,154.

The Two Great Dairy States.—New York and Wisconsin are the great cheese-producing States of the Union, together producing 205,543,875 pounds, or more than two-thirds of all the cheese made in the United States, which is given at 256,761,833 pounds.

The Creamery System.—The creamery system of making butter originated in the United States. The first creamery was built in Orange county, New York, in 1864, and in the following years the industry extended westward. The dairy centrifuge or cream separator made its appearance in 1879, and soon revolutionized dairy and creamery management. The "separator plan" was soon adopted in all new factories, and has replaced the cream-gathering plan in established creameries. The separator, operated by power, is now an essential feature of the creamery and its various branches.

The Separator.—One powerful separator is the usual equipment of a creamery, and does the work for a whole neighborhood. To reduce the cost of transporting milk to creameries, skimming stations have been established at convenient points, from whence the cream is transported to central points. There are 8,286 establishments in the United States using separators, of which about 1,600 have two or more.

The Babcock Fat Test.—The Babcock test is a chemico-mechanical contrivance, easily operated, by which the percentage of butter fat in either milk or cream may be measured with mathematical accuracy. Milk delivered at creameries and cheese factories is now generally tested in this way and paid for on the basis of fat contents or butter-making value.

Creamery Products.—Creamery products are classed as "packed solid" and "prints" or "rolls," 78.3 per cent. of the total product being packed solid and 21.7 in prints or rolls. In some States butter is prepared in bricks, prints or balls weighing half a pound or a pound, or in firkins, tubs or boxes. On the Pacific coast, three-fourths of all the butter made is put up in two-pound rolls.

The Condensed Milk Industry.—Gail Borden, in 1856, established the industry of manufacturing condensed milk in a semi-liquid state, and the product has become known all over the world, both sweetened and unsweetened. In 1900, 50 establishments, operating in 14 States, produced 186,921,787 pounds of condensed milk, worth $11,888,792. New York and Illinois, with over one-half of the condenseries, produced over three-fourths of the entire product.

Consumption of Dairy Products.—The total quantity of butter consumed in the United States in 1900 was 1,474,477,479 pounds, or 19 pounds for each inhabitant; the quantity of cheese consumed was 263,835,179 pounds, or 3.3 pounds per head of population; the quantity of condensed milk consumed in the census year was 173,212,458 pounds, or at the rate of 2.3 pounds per head of population.

Prices for Creamery Products.—The average price obtained for all creamery butter in 1900 was 20.1 cents per pound. Cream sold at prices ranging from 53 to 58 cents per gallon in the greater cream-producing States, and 71 cents in Maine, averaging 57 cents throughout the United States, and averaging a little under two pounds of butter per gallon.

Skim Milk.—The average price for skim milk is 10 cents per 100 pounds for conversion into casein, but it is said to be worth more than this to farmers who use it judiciously as food for young stock.

Cheese Factory Products.—Cheese is the only commercial product of the factory, whey being waste. The latter may be sold as material to make sugar-of-milk. A certain uniformity of type of cheese has been established, known as the "standard American" or "full creamery cheese," often called cheddar; Neufchatel, cream cheese, Brie and Camembert are also made in considerable quantities.

Whey.—There are three or four factories in the United States where whey is converted into sugar-of-milk.

Comparative Summary of the Manufacture of Cheese, Butter and Condensed Milk.

	1880	1890	1900
Number of establishments ..	3,932	4,712	9,355
Capital invested	$9,604,803	$16,624,163	$36,508,015
Number of wage-earners	7,903	12,601	12,865
Wages paid..................	$1,546,495	$4,422,101	$6,170,670
Value of products...........	$25,742,510	$62,686,043	$131,199,277

Dentistry, Mechanical.

Ancient Dentistry.—Dentistry is divided into two branches, mechanical and surgical or operative dentistry. It has developed as a distinct profession only during the past one hundred years, though certain branches were practiced long before. The jaws of mummies afford evidence of dental work in the shape of natural teeth bound together with gold, or artificial teeth of ivory, bone, wood or stone attached to the natural ones by means of cord or gold or silver bands, or ligatures, which were buried five or six hundred years before Christ. Tooth filling was then practiced in some measure.

Ancient Writers on Dentistry.—Among the ancient writers on dentistry were Herodotus, Hippocrates and Aristotle, who wrote 350 B. C.; Erasistratus and others. Though dentistry is known to have been practiced later, there are no known writings concerning it until 1532, when Peter Jordan published a book on it, quoting liberally from ancient writers.

Material Used for Teeth.—Until teeth made of porcelain were introduced, the dentist made use of animal teeth, especially cattle and sheep, hippopotamus tusks, elephant and other ivories and bone. Human and animal teeth were fastened in the mouth by ligatures of gold or silver wire, unbleached thread, sea grass or silkworm gut.

Porcelain Teeth.—Fanchard, in 1728, proposed the use of porcelain, but their manufacture was not begun until 1776. Gold was the first metal used as a base for artificial teeth, and it was introduced by Dr. Gardette, of Philadelphia, in 1787. Other metals subsequently used were silver, platinum, aluminum, tin, beside various metallic alloys.

Gutta-Percha.—Gutta-percha was introduced in England as a base in 1851, and in the same year a hard rubber compound appeared, named vulcanite. In 1855 Charles Goodyear, Jr., patented a dental plate of hard rubber in which the teeth were secured before the compound was vulcanized.

Rose pearl was tried but it fell into disuse. Celluloid was tried but it was porous and less durable than vulcanite. Porcelain and platinum in combination were found to answer better, which is made as follows: A base of platinum is swaged to fit the mouth, the artificial teeth are lined with the metal and soldered to the platinum base; a porcelain body of proper shade is next molded about the necks and root portion of the artificial teeth and on the exposed surfaces of the platinum, and carved and colored to look like the mucous membrane of the mouth. The entire piece is then properly baked to fuse the porcelain.

Crown and Bridge Work.—The present method of inserting artificial teeth by bands, springs or artificial crowns attached to the crown or roots of natural teeth is only a modification of the ancient method. The use of bridges is carried too far sometimes and poorly made ones cause undue secretions of the mouth. Gold shell crowns for bad teeth are often, like bridge work, unwisely used. Filling of some sort would frequently answer better.

Filling.—Filling or obturation properly began early in the nineteenth century, and thin foil or rolled gold was used. In 1846, sponge or crystal gold was introduced. In 1855 the use of cohesive gold for filling teeth was introduced and soon became general.

Platinum is found too harsh, but is used in combination with gold foil or rolled gold where there is severe stress. Silver is not used as it oxidizes. Tin, which is soft and pliable, is sometimes used to fill certain cavities. It yields salts, which seem to possess antiseptic properties.

Plastics.—The earliest plastics were made of preparations of gum resins, such as alcoholic solutions of mastic, sandarac, damar or copal. Amalgams were introduced in 1826. They are a combination of two or more metals with mercury, but as now more generally made, they consist of a combination of three or more metals with mercury.

The filling of pulp canals in devitalized teeth was later introduced. Capping of exposed pulps has been practiced a long time. The dental engine appeared in 1846. The use of the rubber dam to exclude moisture from the cavities during filling has proven a boon to dentistry as well as the introduction of the Esmark bandage.

Inlay Work.—The use of plugs of porcelain, glass, gold, vulcanized rubber and similar materials which are cemented into a tooth cavity was a marked advance and is, with the improved methods of making porcelain, becoming more and more popular. It involves ultimately the use of gold filling in the front teeth.

Electricity in Dentistry.—Electricity is used in dentistry for the operation of mechanical appliances, in a mouth lamp and as a cataphoric current which is employed for diagnostic and therapeutic purposes. Cataphoresis is the forcing of drugs into the diseased tissues by means of the galvanic current. The X-ray is found of assistance in detecting unerupted or impacted teeth, abnormal growths on or about the teeth, imperfect root-canal fillings, resorption of roots, fractures of the jaw or the presence of foreign bodies in the bed from which the teeth have their origin.

Treatment of Loose Teeth.—This often proves to be a knotty problem. Loose teeth often are due to gouty or rheumatic conditions, as to which medical attention is advisable.

Dental Terms.—Replantation is the replacing of a natural tooth in the socket from which it has been forced out. Transplantation is the placing of a tooth in another socket. Implantation is the placing of a natural or artificial tooth in an artificially prepared socket. The implanted tooth does not last long.

Anesthetics.—The chief anesthetic now employed is nitrous oxide or laughing gas. Cocaine as a local anesthetic has almost entirely superceded the use of cold-producing volatile substances, as ether, ethyl or chloride.

Orthodontia.—Orthodontia refers to regulating or correcting the wrong position of teeth and the skill with which this difficult work is done is leading many persons to avail themselves of the services of dentists who develop skill in that work.

Comparative Summary of the Dentistry Material Industry.

	1880	1890	1900
Number of establishments...	20	24	68
Capital invested............	$840,800	$2,908,113	$2,112,236
Wage-earners...............	490	1,011	1,017
Wages paid..................	$237,729	$542,648	$508,603
Value of products..........	$860,758	$2,594,888	$3,721,150

Dyeing, Art of.

Art of Dyeing.—The art of dyeing consists in impregnating fibres, in cloth or other textiles, with coloring substances. Different materials take dyes in different portions and in different methods. The disposition to absorb and retain colors occurs in the following order: Cloth has a great attraction for colors; then follow in order silk, cotton, flax and hemp. If woolen goods are dyed before weaving they are called "wool dyed;" after weaving, "piece dyed."

How Colors Are Defined.—Dye colors are spoken of as substantive and adjective. Substantive colors impart their tint by simple immersion in their infusions or decoctions. Adjective colors require fixing or striking; intervening substances are termed mordants.

Ancient Dyes.—Invention of dye is attributed to the Venetians and to Solomon 1000 B. C., when he sent to Hiram of Tyre for a man skilled in dye works. The Sanskrit speaks of dyeing in many places. The celebrated dye of antiquity was the Syrian purple. Many speak of a dye built up, the fluids of which were obtained from the sac in the throat of two certain animals. One fluid was mixed with sea water, ripened by exposure for three days, diluted with five kinds of water, warmed for six days, being occasionally skimmed, then clarified and applied as a dye for white wools previously prepared by the action of lime-water. The wool was first plunged into the perpura dye and next into the duceinum dye, well known in those times. Dyes and the goods dyed with them are celebrated in the Hebrew and other ancient Scriptures.

Dyes in Our Time.—Prussian blue was discovered in 1710, and aniline in 1836; in 1856, aniline was treated with bichromate of potassus, from which was obtained mauve; a substitute for bichromate of potassa produced majenta, blue, green, violet and other colors. The dyeing industry and the establishment of the various branches of the great textile industry were greatly stimulated by the cultivation of cotton.

Dye Stuffs.—There are 77 establishments engaged in the manufacture of dye stuffs, with a capital of $7,839,034, producing products worth $7,350,748. The industry is located mainly in New York, Massachusetts, Pennsylvania and New Jersey. Among the chief products are natural dye stuffs, artificial dye stuffs, malt and iron liquor and red liquors. At the present time there are several thousand artificial organic dyes or colors on the market. In textile dyeing and printing the substances called forth are largely used either to fix or to develop the color on the fibre. Substances of mineral origin are employed, among them salts of aluminum, chromium, iron, copper, antimony and tin, as well as from substances of organic origin, such as acetic, oxalic, citric, tartaric and lactic, sulphated oils and tannic. "Red liquor" is a solution of aluminum acetate in acetic acid, and is produced by acting on calcium or lead acetate solutions with aluminum sulphate or the double alums. Iron liquor, known as "black liquor," is made by dissolving scrap iron in pyroligneous acids.

The Art of Dyeing.—The art of dyeing has developed voluminous literature. Schools have been established for instruction. A summary, therefore, is beyond the limits of this review. In its broad sense, dyeing consists in the production of color on organic fibres, and surfaces of silk, hair, wool, leather, fur, feathers, bone, ivory, horn, wood, cotton, flax, jute, hemp, paper, etc. When one uniform color is to be given, the process is called staining, when wood, bone, ivory or paper is to be operated upon. When the material can be spun or woven, the process is called dyeing.

Vessels Used.—The vessels used are termed cisterns, kettles, baths, pans, troughs or holes. For black, iron and copper vessels are used; for bright shades, like aniline colors, block tin is used. Goods have to be thoroughly wetted before coming in contact with the dye. They must be kept in motion and it is usual to keep adding dye as the process goes on, especially for wool or silk, because they take up colors rapidly.

Dyeing should be begun at a low temperature and then gradually raised to a boil. Bits of the immersed material are cut off and compared with the original, for which good light is necessary but the direct rays of the sun must be avoided. By this means the dyer can tell if he must keep on or add more dye. No two samples of dye are ever exactly alike, and beside, wools and cottons of different growths and different seasons, vary. A fixed proportion of dye to a given weight of goods does not always give the same shade. The bits cut off are placed side by side with the pattern and judged by reflected light, then compared overhand by holding them up to the light and the eye is directed along the surface. The mind must judge quickly, as the eye is easily fatigued by the chemicals.

Rinsing.—When the right shade is had, rinsing follows in cold water, sometimes at once, sometimes after the goods have cooled, though for some colors rinsing is not permitted. A mordant, which is a chemical preparation whose office it is to fix colors, is applied in the intermediate rinsings. It is often necessary to put in a little mordant and boil the water in order to catch any impurities, then add the mordants or dye wares.

Drying.—After rinsing, drying begins, which should be done in a well-ventilated and not too light room. Many colors can be dried in the open air if smoke or acid fumes are absent.

Specific Gravity.—It is important to know the specific gravity of acids, dilutions of mordants, extracts of dye wares, etc., for which works on dyeing give ready rules.

Mordants.—There are numerous mordants. One, alum, is known under two distinct forms—potash alum and ammonia alum. The acetate of alumina is the most important to the cotton dyer and tissue printer. Among some, the mordants in common use are antimony mordants, chromium mordants, copper mordants and tin mordants. What is known to the trade as tin crystals or tin salts is most important. It is made by dissolving granulated tin in muriatic acid, which is free from iron, arsenic and sulphuric or sulphurous acid. Heat is applied to the mixture, and when the acid is saturated, the liquid is run off and allowed to crystallize. The crystals form needle-like particles which attract moisture.

Mordant is first applied, and this causes the dye to adhere to the fibres. It sometimes effects tints. Mordants were used in China and India in remote periods, and are described by the ancient historians.

Raising Agents.—After the colors have been fixed, the material is subjected to the "raising" process, which brightens them, sometimes by passing it through a weak acid.

Leveling.—Sometimes dyes act unevenly, some parts of the goods taking more than their share. To evenly distribute the color, a little Glauber's salts are added, which diminishes the affinity of the color for the fiber, so that it deposits more slowly and evenly. This is called leveling.

Cotton Dyeing.—Cotton bears contact with dyes better than silk or wool and is more easily injured by strong acid solutions. Aniline mordants help to work certain organic colors on cotton. Aniline black gives more satisfactory colors on cotton than on woolens.

Silk Dyeing.—Silk takes up many colors which can only be worked upon vegetable fibers by the aid of mordants. It takes acid better than cotton but less than wool. It cannot bear strong alkalies.

Wool Dyeing.—Wool is dyed in both the loose or unmanufactured state, in yarns, piece goods and in rags or shoddy, and in all except a few cases at boiling heat. It bears contact with acids better than cotton, but it is more readily affected by alkalies. Superheated steam reduces it to a jelly. The mordants used in wool dyeing are very frequently added to the dye pan along with the dye wares and the goods to be dyed and all boiled together. Care has to be taken to get a level shade on wool yarn and still more so on piece goods.

Summary of the Dyeing and Finishing Industry 1900.

	1880	1890	1900
Number of establishments..	191	248	298
Capital invested	$26,223,981	$38,450,800	$60,643,104
Wage-earners	16,698	19,601	29,776
Wages paid	$6,474,364	$8,911,720	$12,726,316
Value of products	$32,297,420	$28,900,560	$44,963,331

Electrical Apparatus and Equipment.

The Mighty Factor.—The great influence of electrical apparatus and equipment as an agency in the industries and transportation cannot be overestimated. Within twenty-five years 3,117 patents for electrical generation alone have been issued. During the four years ending 1900, 6,796 patents were issued for specific electrical inventions. Until the development of the dynamo, primary batteries were used. The dynamo was an epochal machine, and as its possibilities burst upon the scientific mind of the world, it opened the door to immediate and remarkable possibilities. No machine was ever devised which exerted such stimulating influences upon the scientific and commercial minds of the age. Through it new industries sprang into being.

Sound-Wave Machines.—The first machine to successfully capture sound waves, record them and release them at will, reproducing the exact sounds, was made by Thomas A. Edison, in 1877. The first phonograph constructed consisted of a cylinder with a threaded surface, and was operated by turning a crank. The graphophone followed in 1886.

Up to 1902, 353 patents had been granted for phonographs and graphophones. Phonographs use cylindrical records only; graphophones use both cylinders and disks, while gramophones use entirely the disk records. Disk records ranging from 7 to 10 inches in diameter are etched and then coated with a solution of hard rubber. These wonderful machines have a grand future before them.

Extent of Electrical Industry.—In 1900 there were 580 electrical establishments representing an invested capital of $83,130,943, with a production having a market value of $91,348,889. These figures have no reference to telegraphy, telephony, electric railways, electric lighting, etc.

Number of Dynamos.—According to the returns of 1900 there were in operation 9,182 direct dynamos, and 1345 with alternating current, representing a total horse power of 770,832, valued at $10,472,576. The extension of the use of electrical power is stimulating the production of dynamos of extraordinary capacity, especially in localities where water-power is available. By means of this device industrial methods are being revolutionized and industries are being established in localities where otherwise activities are practically impossible. The increasing utilization of the water-power throughout the world points to wonderful possibilities in the stimulation of energy and in the broadening of the field of human effort.

Average Horse-Power.—The average size of the dynamo has risen somewhat in excess of 75 horse-power. The average size of the alternating current machine is 254 horse-power, that of the direct current alone, 47 horse-power.

Electric Lighting.—Thirty years ago small machines furnished current for arc lamps, and twenty years ago for incandescent lighting of the direct current type.

Since 1890 it has become the practice to use dynamos instead of primary batteries in telegraph and telephone offices. In the newer 10,000 horse power machines the current is generated at a potential of 12,000 volts in the machine itself, dispensing with the "raising" transformers entirely, unless a higher line voltage is desired. These larger machines have effected a reduction from $14 to $7 per horse-power in cost.

Increasing Demands.—The output of direct-current apparatus has been yearly increasing by reason of the presentation of many minor demands, such as electroplating, telegraph and telephone office requirements, requirements of electric automobiles and the requirements of the street railway systems. Companies to supply incandescent lighting were followed about 1880 by companies to exploit arc lighting. About this time the electric railway came into prominence with a motor demanding a pressure of 550 volts.

Central Power-Creating Sources.—These systems have become as one in generating currents by alternators of the polyphase type at convenient points, from which the current can be transmitted at high pressure to sub-stations, where it is converted into direct current for local distribution by means of large storage batteries. This method is applied to both electric lighting and to electric railway work.

Transformers.—A transformer consists essentially of a case of iron plates or wires surrounding or encircled by two coils of copper wire, the coil being of fine wire and the other of thick wire. These coils are enclosed in an iron case, and constitute the transformer of to-day, which is substantially no more than the induction coil known to science for many decades.

Alternating-Current Dynamos. — The transformer pointed to the coming of the dynamo. First came the lightning transformer in 1883, which reduced the 500-volt main line potential from the dynamo to 100 volts in the secondary. Westinghouse made numerous improvements which operated lights but not motors. Next, Tesla's polyphase apparatus for electric motors was introduced and opened up a vast field of possibilities which have been converted into realities.

Switchboards.—There were in use, in 1900, 6,422 switchboards in the United States, of which 3,354 were in Pennsylvania; 2,506 in New York, 180 in Illinois, and so on down. Switchboards are now built of slate or marble slabs, upheld by steel and brasswork. Some boards are built three or four stories high, with stairways, and even with electric elevators passing from floor to floor.

Motors.—Latest official tabulations show an enumeration of 35,604 direct and alternating current motors, representing 515,705 horse-power, valued at $7,551,480. Pennsylvania had the greatest number as measured by value, viz.: $3,204,058.

Motors on Railways. — There were, in 1900, 15,284 motors in use on the railways, constructed in four States—Massachusetts, New York, Ohio and Pennsylvania—representing 666,669 horse-power, valued at $7,568,841.

Giant Strides.—While electric motors had been known for three-quarters of a century, they assumed no place in the industries of the world. But, when the mighty dynamo came, and it was discovered to be reversible, that is when the current is supplied to it, it would run as a motor, a grand start was made in the use of electrical energy in steam plants and factories, mines, water works, docks, warehouses, steamships, office buildings, and in a hundred other ways.

Electric Railway Work.—The stimulus given to electric railway work is shown by recent statistics, which show the total capital and funded debt of all roads in 1890 to be $363,000,000; in 1900, $1,800,000,000.

Motor Equipment.—In 1890 a car equipped with a pair of 15 horse-power motors was well equipped. The average per motor at present is considerably over 40 horse-power. This capacity is being increased, and in the opinion of electrical engineers there is no theoretically assignable limit.

Storage Batteries.—The storage battery of today is of the lead-lead type. Investments in the storage battery industry exceed $11,000,000, with a minimum capacity of 300,000 horse power hours. Special types of batteries are made for different classes of work, the greater bulk going into central stations for light and power, isolated lighting plants and street railway power houses.

Primary Batteries.—There are three classes of primary batteries—liquid, testing and dry. The cheap production of current by the dynamo is leaving less for the primary battery to do. In the primary battery where the consumption of zinc alone for a given time is ten cents the cost of coal at the dynamo central station is one-half cent.

Carbons.—Charles F. Brush, of Cleveland, Ohio, discovered that coal-tar pitch was the best adhesive material to bind the particles of carbon together. This laid the foundation of the industry which in 1900 produced 172,955,922 carbons for arc lamps.

Graphite.—The artificial production of graphite by electricity was effected in 1897 by subjecting carborundum to a heat that would volatilize the silicon, leaving the graphite. In this process the regular charge of coke, sand, salt and saw dust is packed around a carbon core, the current through the core being so regulated as to first form and then decompose the crystalline carbide of silicon.

Arc Lamps.—Latest authentic estimates show the number of open arc lamps at 50,000, enclosed 250,000. This light as all know is created by the passage of current between two slightly separated sticks or pencils of carbon. One of the chief drawbacks in arc lighting has been in spite of the volume, brilliancy and cheapness of the light, the labor of inserting carbons, which is a serious item. This has been overcome by enclosed arc lamps in which the arc burns in a residual atmosphere of carbon monoxide and nitrogen in a heated, rarified condition. In 1900 the production of enclosed lamps was six times greater than the open arc lamps.

Search Lights and Projectors.—There are in use some 10,000 search lights and projectors, of which four-fifths are in New York. The largest lamps obtainable range from 50 to 150 candle-power, and are used for stage lighting, ship lighting and military operations and marine work.

Incandescent Lamps.—The number of 16-candle-power incandescent lamps foots up 21,191,131; below 16 candle-power, 2,906,817; aggregate value, $4,000,000. New Jersey leads in production, Ohio follows and Massachusetts is third. Lamps are now usually manufactured of 4, 6, 8, 10, 16, 20, 32, 50, 100 and 150 candle-powers, 80 per cent. being 16 candle-power. There are over 10,000 varieties.

The Nernst Lamp.—The light-giving feature of the Nernst lamp is a small white rod, composed in part of rare earths. This rod, when cold, is non-conducting. Conductivity rises as it is heated, and after a few seconds the glower bursts with full incandescence. The range of this lamp is from incandescent at 150 candle-power to the arc light at 1,200 candle-power. Ninety per cent. of its illumination is well below the horizontal line.

Telegraphs.—The latest official summary gives the number of telegraph instruments in the United States as 199,410, besides 40,264 in police and fire service. Notwithstanding the progress made in systems of duplexing and quadruplexing, a very large proportion of work is done by key and received by sounder. In machine telegraphing, messages are prepared by punching holes in a tape, which is afterward run rapidly through a mechanical transmitter, to be received at the other end by an ink writing-in machine, in which the dots and dashes are properly recorded on another tape for subsequent translation into words.

Wireless Telegraphy.—If anything be thrown into a pool of water, rings or ripples of undulation are caused, which pursue each other to the bank. This principle applied to ether is wireless telegraphy; the mechanical appliances utilized set up these wave-like motions in the ether.

The Transmitting Apparatus.—The transmitting apparatus consists essentially of a special induction coil. When the operator presses the key, the current from the battery energizes the induction or spark coil, which in turn charges the "spheres" and a vertical wire in such a manner that electrical disturbance is thrown off by the vertical wire, and thus causes displacement waves to ripple in the ether. This vertical wire becomes a radiator of electric waves in every direction, as a stick thrown into a pond would cause little waves to radiate.

The Receiving Apparatus.—The receiving apparatus consists of a receiving vertical wire running down to the coherer, placed in a circuit containing a local battery, and a sensitive telegraphic relay, actuating in turn another circuit containing a "trembler" or decoherer and the recording instrument. The "soul" of the whole business is the coherer, which is a small glass tube about the size of a gold pencil, wire running in at both ends, but separated slightly, which space is filled with filings of a mixture of nickel and silver.

The Filings.—Keep your mind on these filings, for it is in them the connection is made between the ether and the atmosphere. When ether waves impinge the tube, the filings between the two metallic pole pieces in the tube cohere—i. e., apparently pull together into a sort of string or conductor, and thus become a conductor to the current, which immediately flows into the local circuit from the local battery, and the signal is recorded by the receiving telegraph instrument.

How It is Done.—It is by the opening and closing of the circuit that the sending and receiving of messages is accomplished. When the filings fall apart, the circuit opens to receive the next etheric impulse. This falling apart of the filings is caused by a hit on the tube by a little tapper or decoherer. By this process of cohering and decohering the signals are received, and can be heard by the ear or recorded on a tape register or heard in the telephone. Filings of carbon, cobalt and carbon dust are also used in the tube, as well as others of an electro-magnetic nature, and by taking advantage of the law of magnetic hysterisus, which manifests itself in iron under certain conditions, it is possible to prevent the reading of messages by others than those for whom intended.

Insulated Wires and Cables.—About the year 1857 the art of braiding wire was developed. Numerous patents wrought minor improvements, until electric requirements brought about radically different methods of insulation. One of the most notable improvements is the use of paper in insulation; paper cables are now manufactured in increasing quantities for all classes of work. Experience has shown that paper thoroughly impregnated with insulating compound, such as the various tars or resins, forms one of the best insulating materials, provided the paper can be kept reasonably dry, which can be insured by the use of lead sheaths.

Electric Conduits.—Two systems of building electric conduits prevail, the solid system and the drawing-in method. In the "solid" method short sections of tube are joined together and the conductors are solidly embedded in insulating compound. In the "drawing-in" method ducts of metal, cement, terra-cotta, wood, etc., are laid, and then insulated cables are inserted by pulling in. At this time cement-lined iron pipes, terra-cotta conduits and concrete blocks, perforated, are used in underground work.

Interior Conduits.—The present system of interior tubing for wires is the result of various improvements. At first paper was wound spirally into a tube and dipped into an insulating material, then sheathed in brass. After this conduits were made with an outside wall of iron or steel. Much conduit material is now made of textile fabric and metal pipe, dipped in enameling substance.

Electric Heating.—The principle of electric heat apparatus depends on resistance offered by some form of metallic conductor to the flow of the current through it. This conductor surrounds or is surrounded by a non-inflammable heat-conducting substance. In some types metallic paint is fired upon strips of mica, thus affording high resistance with a maximum of radiating surface. Electric heating apparatus is being widely applied in mechanical operations and with evident economic advantages.

Lightning Arresters and Fuses.—Many forms of lightning arresters are made, and the annual output ranges from twelve to fifteen millions. Arresters which protect large circuits and heavy electrical machinery consist of numerous disks, arranged to break up the discharge on receiving it, or of electro-magnetic coils to "choke" the discharge and direct it into the arrester. Another good arrester has seven cylinders, which give six-spark gaps in series in each unit. The General Electric Company has an arrester which consists of three or more brass cylinders, connected in series with current-resisting rods installed with the choking cells between them.

Electric Measuring Instruments.—There are various distinct groups, viz., electro-magnetic, electro-static, electro-chemical, electro-thermic or hot wires, tangent galvanometer, dynamometric and the Weston. Central station voltmeters and ammeters have come into use, in which a coil suspended in a strong field between the poles of a magnet can rotate through a small angle when the current passes.

Electro-Static Instruments.—These instruments depend for their action upon the mutual attraction of two plates connected with the opposite sides of the line or circuit when any difference of potential exists between them.

An enumeration of electrical devices and of electrical equipment for all manner of industrial uses would prolong this review beyond its intended limits. The electrical industry is now the most promising one and promises to revolutionize many industrial processes.

Comparative Statement of Electrical Apparatus and Supplies Industry.

	1880	1890	1900
Number of establishments	76	189	580
Capital invested	$1,509,758	$18.997.337	$83,130,943
No. of workers	1,271	8,802	40,890
Wages paid	$683,164	$4,517,050	$20,190,344
Value of products	$2,665,036	$19,114,714	$91,348,889

Electric Generators and Motors.

Early Steps Toward the Generator.—One of the first applications of electricity along pronounced modern lines was in 1871, when a machine was made for killing whales by electricity, the first of its kind. The next was a machine for seaboard illumination. Soon after a machine was introduced having a continuous armature winding, which may be regarded as the progenitor of the modern dynamo electric machine. This was patented in 1871, and was followed by appliances for exciting the field magnets by the currents generated in the machine. A multipolar self-exciting machine soon followed, and Brush appeared with a machine having an open coil-ring armature. In 1878 another machine appeared which had all the essential features of the most modern machines.

Brush.—Brush introduced his teaser, which was a high-resistance winding upon the field magnet, connected in shunt to maintain the magnetism of the field magnet when the machine is running, whether the external circuit was closed or open.

Edison.—Edison, in 1879, introduced the cylindrical armature, which was followed by three-cell armature; next came a regulator consisting of a shunt around the field magnets, including a variable resistance, and in 1880 a multipolar alternating current machine was introduced, having a portion of its current communicated for exciting the field magnets.

Van de Poele.—Van de Poele introduced the motor generator, or rotary transformer, which had two armature windings, one taking current from a line and driving the machine as a motor, while the other winding acted as a generator; his next improvement was a device known as carbon collector brushes. This little history of inventions is a necessary preliminary in order to understand the more perfect machines of to-day.

Gas Engines.—One of the more modern improvements was brought out by Westinghouse in 1900, in which gas is supplied for running engines at the different divisions of his railroad. These engines drive dynamos for supplying each its own division, and they are provided with signaling and controlling devices for the management of the local engines.

Separate Motors.—One of the interesting features of the application of electric power in manufacturing is the use of separate motors to individual machines, by which the output of an establishment can be increased as high as 50 per cent. over what the same machines turned out when operated by belt transmission. The principal cause of this gain is the facility with which each machine can be run at the maximum speed for the particular work it is doing.

Supplanting Shafting.—This method of separating power supplants the use of line shafting and belt transmission. When any of the units are not in use, the motors are shut down. Manufacturers of electrical equipments have designed a large number of electrical machines of various types to answer all the requirements of many manufacturing plants. One of these is the encased machine, especially adapted to out-of-the-way places where it can receive but little attention. There are machines, known as semi-encased, where the peculiar features of construction permit running at a higher output than in cased machines. Other machines are specially adapted for use as generators which carry high overloads. Certain types of machines are built to run three different speeds — moderate, intermediate and slow. The advantage of lower speed is diminished wear on the belts, bearings, commutator and brushes.

Series Wound Motors. — Series wound motors are very generally used for heavy work in which the motor has to reverse its direction of rotation, and is specially applicable for operating trains, rolling and bending machinery and the like. In these machines the field coils are connected in series with the armatures, so that the full current passes through both the armature and the field coil.

The construction of all first-class motors is such that the heavier the load thrown on the motor, the stronger will be its field. The construction is also such that when the motor slows down with the heavy loads thrown upon it, they try to keep the load from increasing or decreasing above or below the normal value.

Compound Winding.—Compound winding is a combination of the shunt and series types, and in a great measure combines the advantages of both. The shunt field prevents the motor from speeding up too much when the load is thrown off, and the series field gives the motor greater strength or "starting torque" when starting. The series coil helps the motor to carry heavy loads and avoids trouble from sparking with excessive loads. Compound wound motors are quite generally used where a single motor is installed to drive an individual machine. The advantage of a compound motor where there are fluctuating loads to handle is, that the shunt field holds the motor at sufficiently constant speed, while the series field gives the motor additional strength and cuts down the rush of current from what would otherwise occur.

Service.—The compound motor is also serviceable for driving ordinary machine tools which have to be started and stopped and reversed as the series coil cuts down the current consumption during the periods of starting and reversing. Certain motors are especially made, adapted for running punch and printing presses, on account of their steadying effects on the power circuit. They are also desirable for use with fans, as the power consumed by the motor does not vary so much with the different degrees of moisture in the atmosphere. The shunt field offers the means of readily adjusting the speed of the fans.

Two Methods for Regulating Speed.—There are two general methods for regulating the speed of motors. The simplest method is to insert an adjustable resistance to the armature circuit; the second consists in varying the strength of the field magnets; the other method of speed control is often used where the waste of power in the regulating rheostat would be too large an item, or where it is desirable to get practically constant speed irrespective of the load.

Putting a Rheostat in the Shunt Field.—The principle on which this method operates is, that weakening the strength of the field magnets reduces the counter electro-motor force of the armature, and the armature is forced to increase the speed in order to increase the counter-electromotor force to a suitable value. This is accomplished by putting a rheostat in the shunt field circuit, or by using a controller which will vary the number of effective turns in a series winding. The resistance method of control is applicable to any type of motor, whether series, shunt or compound wound.

Speed Regulators.—A method of varying the speed of motors which is coming into quite common use where there are two or more separate voltages available—such as in the three-wire system—simply consists in throwing the armature from one voltage to another, and which makes the motor run at speeds varying in the same ratio as the two voltages.

Multiplied Use of Motors. — The greatest increase in the use of small motors is in manufacturing establishments. This demand has been an incentive to the electrical engineer and to the manufacturers of electrical machinery. Motors are now directly connected to the line shaft as required. Where there are many small lathes and other light machinery, a motor can be placed so that it may be belted direct to the line shafting in the room, or it may be suspended from the ceiling and belted, geared or direct connected to the shaft line, as desired. Motors may be direct connected to individual machines, giving a system most flexible and suited to every condition. These motors are now being widely used in all manner of manufacturing plants, from the largest to the smallest.

Electricity and Electrical Workers.

Light and Power.—Electric lighting is classified into incandescent and arc lighting systems, direct or alternating current and current or potential systems. The unit of light is a spermaceti candle, ⅞ inch in diameter, so proportioned as to burn 120 grains an hour. A candle-power of light is the number of lights of unit intensity that would be required to equal its own intensity. Six such candles weigh one pound. The unit adopted by the International Congress of Electricians at Paris in 1884 is the light emitted by a square centimeter of melted platinum at the temperature of solidification. This unit is equal to 19.7 standard candles. A photometer may be used to measure the candle-power of light. It is known that the resistance of an incandescent lamp is equal to the electro-motive force divided by the current, and that the efficacy is measured by the amount of electrical energy consumed per candle-power, or the watt per candle-power. One of the best lamps for series working is the Bernstein, where the filament is made by carbonizing a silk braid of fine texture connected to two pieces of iron wire, and these to the platinum wires, which pass out through the glass.

Different Systems.—The simplest system of distribution requires a constant current generator, the same current going successively through each arc and incandescent lamp on the circuit. Its disadvantage is due to the necessarily high E. M. F. The multiple series system is now but little used. The parallel or multiple system is the most common, in which a constant potential dynamo is used. The loop system was devised, which overcomes somewhat the drop in potential. The three-wire system gives the advantage of a high potential, and there is the further advantage of having two voltages, allowing the operation 110 or 220 volt meters. The seven-wire system requires six-dynamos. The alternating current system is especially applicable in the lighting of large areas, by which the current is transmitted at a voltage of 1,000 or more by a comparatively small wire at little loss.

Generators.—The type of generator used is determined by the system of distribution. The direct coupling of engines and dynamos has great advantages and calls for high-speed engines. Accumulators or secondary batteries have been applied to electric lighting to a considerable extent, because of the wide variation of load.

The Field of the Nernst Lamp.—The Nernst lamp, instead of being a thread of carbon, is a rod of porcelain or glower about one-thirty-second of an inch in diameter and one inch long, which is heated to a very high temperature by the current passing through it. The glower is fastened to the holder by small platinum wires and aluminum plugs. The energy consumption is about 88 watts per glower, and its life is about 800 hours; that of the heater, about 2,500 hours. The lamps are made only for alternating current circuits from 200 to 240 volts.

Electric Railways.—The circuit passes from the generator to the line, then by the trolley through the car motors; the return current is formed by the rails, connection being made between these and the negative terminals of the generator. There are two methods of motor suspension in use—the nose or wheelbarrow method and the parallel side-bar method. Among the methods used to stop a car by electrical power are storage batteries, the line current and the motor as a generator. The first of these has not come into practical use on account of the expense; the second, depending on the line current, is not very reliable; by the third method the motor itself is made to stop the car. In this case, the motor acts as a generator, the line current being switched off. The current thus generated, due to the momentum of the car, is led through a low resistance, and the motor is thereby short-circuited. This system has the advantage that it is self-contained, and does not depend on the line current.

The Street Car.—The electrical equipment of a modern street car usually consists of two motors, two gears, two pinions, two controllers, one resistance box, one lightning arrester, one choke coil, two canopy switches, one fuse box, one trolley. The methods most frequently employed for supporting the trolley wire are the span-wire system and the bracket system. When the current is fed into the circuit at various distances, a section insulator is used to secure proper insulation.

The Feeder System.—The feeder system is used to prevent the great potential drop because of the impossibility of increasing the size of the trolley wires beyond certain limits. It is customary to arrange the feeders and distances between the feeding points so that when the total number of cars are being operated at average distances apart, the drop will be nowhere greater than 50 volts.

Bonding.—When the ground return is used, a continuous path for the electrically welded joint on rail bond is the most efficient; melted cast iron poured into a mold surrounding the joint has been used to answer the purpose of a bond.

Electrolytic Effects.—Under favorable conditions about one-half of the total current returns to the power-house through the rails, about one-eighth is diffused through the ground, and the remainder is conducted by water mains, etc.

Power Stations.—The essential features of the power station are the machines for generating the current, the engines to drive the generators, and the boilers to supply the power that runs the engines. The electrical features are the switchboard, leads, connections, feeders, measuring appliances and safety devices. Generators for electric railways are generally compound wound, to give as nearly as possible a constant potential of 500 to 550 volts.

The Alternating Current.—The alternating-current system is destined to become an important factor in the future development of electric railways. The transmission of power from a single generating station for railway service by alternating currents is practicable over distances up to 100 miles. By the use of the storage battery, practical results are obtained, but the principal difficulty encountered is in electrical overloads or undue and sudden calls for power upon the battery. The great weight of batteries is another objection.

The Third-Rail System.—The engineering advantages of the third-rail system are manifested in providing for a conducting capacity equal to a very large copper cable, so that on many light traffic lines copper feeder cables are not necessary. The service rails are used as the return current, and are thoroughly bonded. The path of the current on "third-rail" roads is from the third rail to the shoes, through a copper cable to the circuit breakers, to the lightning arresters, through a choke coil to a point where it divides into two parts, each going to a controller at opposite ends of the car, then to the resistance, back to the resistance contacts in controllers to motors and ground.

Multiple Unit System.—The "multiple" unit system, now coming into use, obviates the difficulty before experienced of obtaining a rapid acceleration of the train and of vibration. In this system each car is complete. In the multiple system there is a "motorman" or his equivalent on each car.

The Three Systems.—Three systems are used in the United States, viz.: The Sprague system, the Westinghouse system and the General Electric Company's system. The individual motor controllers are operated by a small master controller on the car platform. In the Sprague system the master controller operates a small pilot motor, which turns the controller cylinder when the current stops; a solenoid spring brake clamps the armature shaft, stopping it instantly.

Westinghouse System.—The Westinghouse system revolves the controller by a ratchet and pawl mechanism driven by compressed air acting in a piston as in the air brake. Valves which are electro-magnets, and which are operated from the master controller or multiple control switch on the car platform, admit the air to the cylinder.

General Electric System.—In the General Electric Company's system there is no main controller of the customary type. Its place is taken by thirteen separate switches, electro-magnetically operated from the master controller.

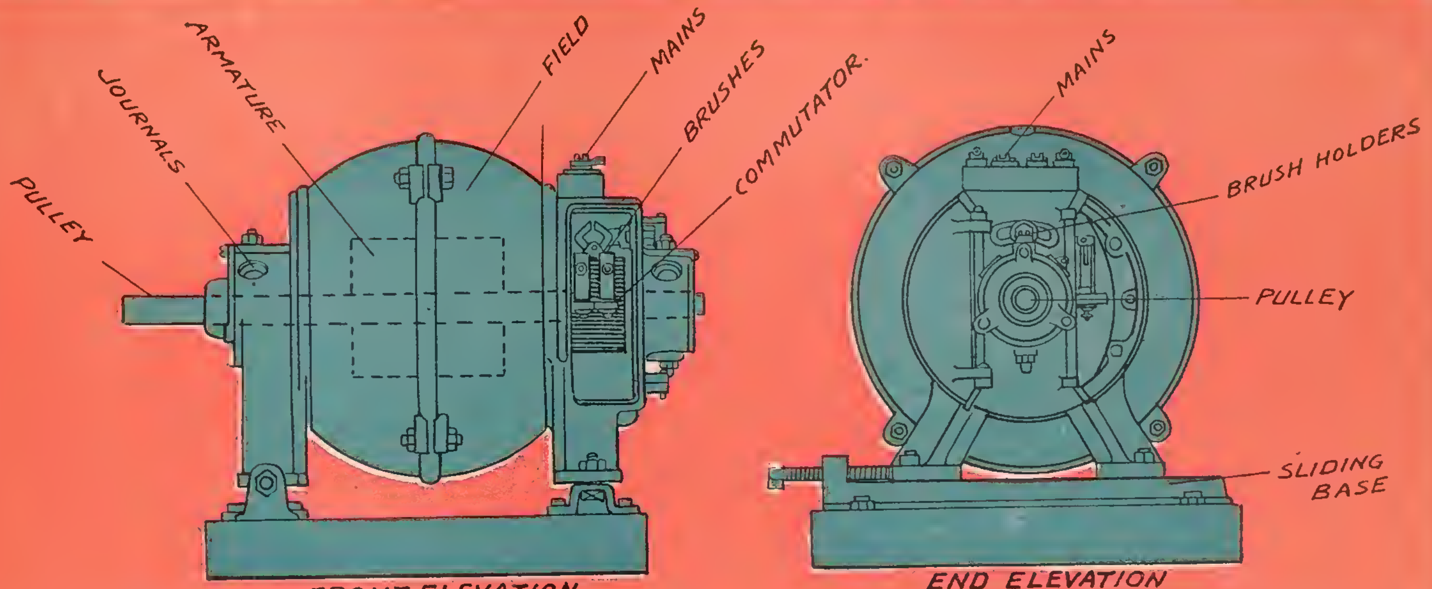
All these systems have the necessary reversing switches and elaborate interlocking and automatic devices for cutting off the main current in case of accident to any of the circuits.

Central Stations.—The best type of central station has brick or stone walls and iron roof, though small stations are built of wood. A fireproof partition should separate the dynamo and engine-rooms. The foundation usually consists of concrete and brickwork, the bricks being laid in cement mortar. If the machine has a cast-iron base, it can be laid upon the brickwork, otherwise it should be capped by a slab of stone.

Compound System.—Compound condensing engines are now more generally used than any other form, and dynamos of large capacity are almost always directly connected to the engines. The usual arrangement is to extend the engine shaft and mount the armature upon it.

Circuit Breakers.—Circuit breakers have recently come into extensive use, especially upon switchboards. They have the same purpose as fuses, are more reliable, and are commonly used in circuits carrying heavy currents. There are three classes of switchboards for direct current low potential circuits, one for alternating current, high potential circuits, and one for series arc lighting circuits.

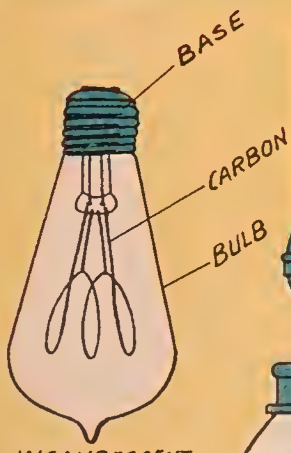
ELECTRICAL INDUSTRY.



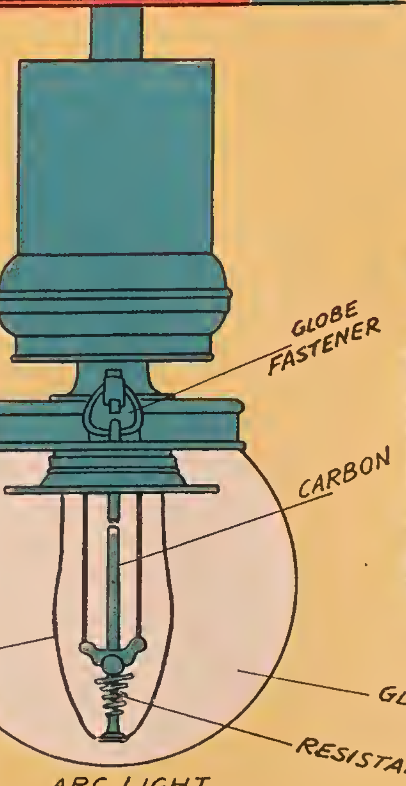
FRONT ELEVATION

END ELEVATION

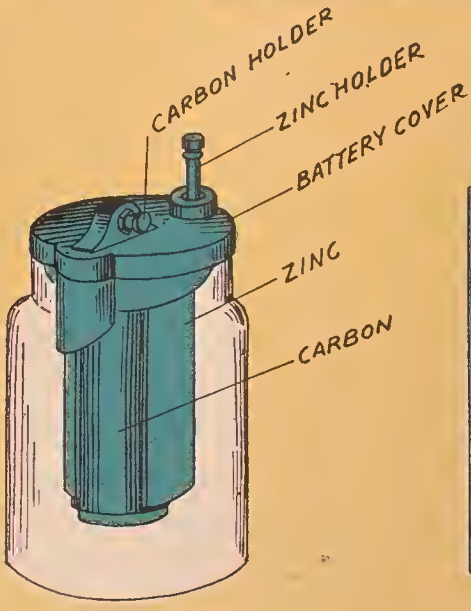
	Nº OF ESTABLISHMTS	WAGE EARNERS	WAGES PAID	VALUE OF PRODUCT.
ELECTRICAL APPARATUS AND SUPPLIES.	580	40,890	$20,190,344	$91,348,889
ELECTRICAL CONSTRUCTION	1,162	5,949	3,312,126	15,907,620
ELECTRO PLATING.	432	2,275	1,036,750	3,007,455
ELECTROTYPING & STEREOTYPING	140	2,408	1,458,977	3,772,025
PHONOGRAPHS & GRAPHOPHONES	11	1,267.	608,490	2,246,274.



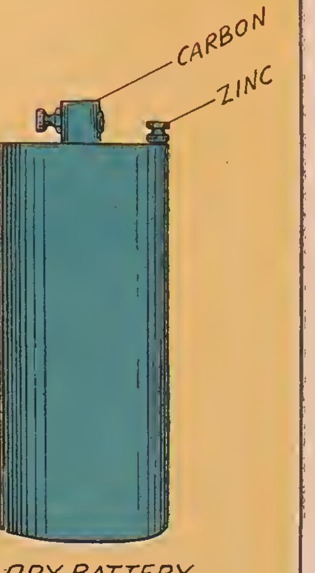
INCANDESCENT LIGHT



ARC LIGHT



WET BATTERY



DRY BATTERY.

Loss in Transmission.—The loss in transmission of power by electricity is divisible into three dimensions—the loss in making the transformation into electrical energy at the generating station, the loss in transmission along the line, and the loss in transformation at the receiving station.

Voltage in Use.—With alternating-current systems about 50,000 volts is the present limiting value. In direct-current systems the voltage is limited by the nature of the apparatus used. The highest working voltage of constant potential machines of the direct-current type is about 500 to 600 volts. In the three-wire system the voltage between the outside wires may be 1,000 or 1,200 if 500 or 600-volt dynamos are used.

Polyphase System.—Two-phase and three-phase systems are the only polyphase systems which have become common. One great advantage of these systems is their value for operating motors.

Aluminum for Electric Conductors.—The conductivity of aluminum varies from 60 to 65 per cent. to that of copper; the best commercial grades have a conductivity of 99.6 per cent. of pure metal. Its low specific gravity and high conductivity have rapidly brought it into use for long power transmission lines.

Storage Batteries.—Storage batteries consist of cells in which a chemical change is brought about by passing an electric current through them, thereby rendering them capable of giving back electrical energy. Ordinarily, a storage battery consists of two sets of plates suspended in a chemical solution. The leading types of storage batteries are Plante, Faure, combination of Plante and Faure, and non-lead. The chief difficulty with the Plante battery was the great length of time to "form" the plates. In 1881 Faure pasted lead oxide or active material directly on the plates, but the element, not being an integral part of the plate, disintegrated. Any primary battery will act as a storage battery, provided its chemical action is reversible. The Gould, the Crompton-Howell, the Electric Power Storage (E. P. S.) battery, sometimes called the Faure-Selton-Vockman cell; the Exide battery, the Chloride battery, which is a combination of the Plante and Faure types; the Tudor cell and Lithanode, and the Edison storage battery, are all in extensive use.

The Booster.—In the regulation of the generator in charging storage batteries, it is customary to maintain the charging current approximately constant for considerable periods, otherwise it would be difficult to determine the quantity of energy put into the battery and its efficiency. The best plan is to make use of a booster, the duty of which is to vary the voltage of the battery terminals with the variation in load, causing charging or discharging of current, as conditions may require. The shunt booster is a shunt dynamo driven by any source of power having its armature circuit in series with the line from generator to battery. The series booster acts to compound the battery on discharge, and tends to maintain a constant voltage on the line. The compound booster is used on railway and power circuits with great fluctuation in load, the battery acting to prevent excessive drop and to assist the generating machinery in carrying the load, relieving it from the strain of sudden rushes of current. The constant current booster is used in systems having short lines and small drop, where it is desirable to have the voltage fall on the sudden application of an overload, so as to prevent the rush of excessive current.

Efficiency of Storage Batteries.—The efficiency of any apparatus is the ratio between what it gives out and that which it consumes. In a storage battery it is the ratio of the amount of discharge to what is put in, to bring the battery back to its original condition after a discharge. The most serious troubles which occur in storage batteries are sulphating, buckling, disintegrating and short-circuiting of the plates. Sulphating may be removed by scraping the plate. Buckling is caused by uneven action on the two surfaces; this is remedied by placing the warped plate between boards under pressure. Disintegration results from the formation of scales or blisters. Short-circuiting may be caused by the dropping in of foreign matter and the formation of sediment, which is removed by syphoning the electrolyte after taking out the plates.

Utilities.—The principal uses of storage batteries are to furnish portable electric apparatus with power, to make up for fluctuations, to furnish energy at certain hours, to aid the generating plant, to make loads more uniform, to transform from a higher to a lower potential, to subdivide the voltage, to supply current from local centers or sub-stations, to supply current to electrically driven vehicles, to supply telephone and telegraph systems, for car-lighting purposes, and as sources of constant potential and current in electrical laboratories.

The complete control of a battery in an electric lighting plant requires provision for feeding the lamps from either the dynamo or battery separately or from the two working in parallel. Three switches are required. The regulation of storage batteries is difficult, because the voltage falls continually from the beginning to the end of the discharge. The total decrease may amount to 18 per cent.

A Recent Invention.—The latest important improvement in electrical devices is a Westinghouse invention, which consists of a single-phase apparatus by which the single-phase alternating current electric system can supplant the direct current system. This invention is designed to do away with the sudden starting and stopping of street-cars, and it does away with sub-transforming stations. The system is less expensive to install and costs less to operate.

Speeds.—Very high speeds can be had with the single-phase alternating current and without any wear and tear at starting or stopping. It it equal to the handling of the heaviest trains. Its introduction will stimulate the substitution of electric power for steam power in suburban traffic, as well as in long-distance traffic. It is proof against electrolysis, and does not offer trouble to the network of utilities by which cities are served with gas, water and sewerage conveniences.

The Following is a Comparative Summary of the Condition of the Electrical Industry in the United States as to Electrical Apparatus and Supplies. The Growth has been Simply Enormous.

	1880	1890	1900
Number of establishments...	76	189	580
Capital invested............	$1,509,758	$18,997,337	$83,130,943
Wage-earners...............	1,271	8,802	40,890
Wages paid	$683,164	$4,517,050	$20,190,344
Value of product...........	$2,655,036	$19,114,714	$91,348,889

In 1900 there were 10,527 dynamos in the United States, representing 770,832 horse-power, and valued at $10,472,576; also, 36,513 transformers, representing 407,451 horse-power, valued at $2,960,171; 6,422 switchboards, valued at $1,846,624; 35,604 motors, representing 515,705 horse-power, valued at $7,551,480.

Elevator Making.

The Elevator's Influence.—No one device or invention has been indirectly the cause of such a revolution in building, and it might almost be said in architecture, as the simple means for ascending the interior of a building as the elevator. It suddenly transformed conditions and opened wide the door of possibilities. In these days when commercial necessities demand the greatest possible concentration of business interests, it is absolutely necessary that means be found for bringing as many people close together as possible. Before the coming of the elevator the six-story building was an exception. Its coming made the 30-story building a possibility. But for the elevator, the immense office buildings of to-day would be unknown, and their advantages from every point of view would also be unknown. By use of the elevator, buildings can be run up to any desired height, and many more business interests can be concentrated into a narrow space.

Kinds of Elevators.—The elevator has certainly revolutionized many commercial methods and has opened up many opportunities. At the Centennial Exhibition the slowly creeping elevator there shown was regarded as a wonder. To-day the rapid-shooting elevators of immense power are known to all who have occasion to visit our great commercial centers. They are of various kinds and operated by various powers. The mechanism, while simple, presents features of complexity, and improvements are being constantly made to gain time, speed, capacity, and give greater assurances of safety. Elevators might for convenience be divided into passenger, freight and grain, with which might be associated conveyors, though they do not belong to the elevator family.

Function of Elevators.—Simply considered, an elevator is an apparatus for hoisting or elevating persons or goods from one level to another. Elevators are indispensable in tall buildings, and in certain portions of the West are used for transferring grain from car to ship, where, strictly speaking, they are conveyers. They are used in flour mills to carry wheat to higher floors, in manufacturing plants and warehouses to carry freight and material, and in offices, to transport persons.

Improvements.—Elevators are now being constructed with a view to the saving of power and to securing greater service out of a given power. The mechanical devices and applications employed to this end are highly ingenuous and meritorious. Among some of the improvements may be mentioned a special worm end gear, belt shifter and brake, slack cable attachment, automatic stop and automatic hatch doors, which are chiefly used on power elevators in stores, factories, mills and warehouses. The worm end gear can revolve at a high rate of speed with a steadiness of motion not obtainable in the ordinary type of screw gearing. The diameter of this improved device is constantly changing as it revolves, and one tooth or thread does not exactly follow in the track of the preceding one, which makes it impossible, when properly lubricated, to cut or unduly wear the teeth of the worm or wheel. The strain being distributed over so much bearing surface reduces the friction, which means less power to drive it. The latest screw end gear shows an efficiency of 56.25, while in the ordinary screw end gear 43.25 is regarded as good work.

Other Improvements.—The belt-shifter and brake has been recently improved, and the improvement is due to the fact that there is no link motion. The arrangement is such that while either of the belts are being shifted to the fast pulley the other remains undisturbed. The newest brake does not touch the pulley until it is brought into use, and by means of a compound lever and weight, the wear is taken up automatically, thus obviating the necessity of frequent adjustment.

Perfection of Devices.—Among other improvements to be noted is a slack cable attachment which shifts the belt and applies the brake, stopping the machine as soon as the suspension cable slacks up. Another is in hatch doors with adjustable crank levers, which open the doors as the car descends. Electric elevator engines have been brought to a very high state of perfection, and are adaptable for variable loads.

Most of the recent triumphs of genius in elevator building are surprising in their efficiency, in the loads they can lift with safety and the steadiness with which they run. Much mechanical ingenuity is being expended on these wonderful conveniences, and a vast field is opening up in which the adaptation of elevators will be carried to a still higher degree of perfection.

Passenger Elevators.—Passenger elevators for dwelling-houses are being built which possess every element of safety. Some have an electromagnetic main switch, by which the motor is started in either direction or stop, a starting push-button at each landing and one at the car. An automatic rheostat insures a gradual admission of current to the motor, and an electric safety brake is applied instantly when the switch is opened, bringing the car to an easy stop, and which will apply automatically in case the supply of current should fail. It has landing switches, and stops the car automatically at any landing that a person may indicate. It has an indicator or dial on the car, by which the passenger indicates the landing at which he wishes to stop. It has also a stop switch on the car, by which a passenger may stop between landings, also safety switches on well doors which prevent the operation of the elevator unless the doors are closed.

The Centrifugal Governor. — This is located either on the car or over the hoistway, where it operates the safety catches on the car by retarding the rope, which is fastened to the car and drives the governor.

The rack and pawl is adapted to slow-speed cars. One form of safety catch grips the smooth steel guide rail, another is operated by the ropes leading to the hoisting machine. Wood guide rails form the easiest means of bringing an elevator car to a safe and gradual stop when descending too rapidly. The sharp-toothed cam is effective, provided it does not impinge too much. The best steel-rail gripping device has vise-like jaws that are supposed to slide far enough along the rails to stop the car easily.

The Air Cushion.—The air cushion, formed by the lower part of the hoistway, was invented by Albert Betterley in 1857. The Ellitthorp air cushion is located at the bottom of the elevator shaft, and no matter from what height a car drops, it will fall to its place without a shock. The depth of the air cushion should be in the proportion of 1 to 6 of the distance traveled. In the bottom of each shaft is a suction valve which opens inwardly as the car ascends, thus preventing the vacuum which would result from the car leaving the cushion. There is also a valve which opens outwardly, and it is so adjusted as to sustain the weight of the car under ordinary conditions, but will, in case of accident, relieve the cushion of undue pressure when the car falls. It has been calculated that the pressure in the air cushion, if a car should fall from the top of a twenty-story building, would be 3½ pounds per square inch. In a test made in a twenty-story building, a car weighing 2,000 pounds was dropped, and the eggs and incandescent lamps placed in it were uninjured.

Three Types.—There are three types of hoisting apparatus — the drum, hydraulic and screw. Modern improvements have increased the efficiency of worm gearing from 30 to over 80 per cent., though spur-gear elevators are largely built.

The Drum Elevator.—The drum elevator is convenient to overbalance, and the counterbalance is made to balance the car with an average load. This arrangement of placing the machine on top of the hoistway is best adapted to electric elevators. The right and left-hand worm gears, interlocked by spur gears bolted to them, are considered the best in use. The duty on drum elevators ranges from 2,000 pounds at 300 feet per minute to 6,000 pounds at 100 feet per minute, varied by drums from 36 to 60 inches in diameter, and motor speeds from 470 revolutions per minute to 1,000 revolutions per minute.

The angle of maximum efficiency on worm gearing is 45 degrees. The advantage of the vertical cylinder over the horizontal is in the counterbalancing effect of the piston and parts moving with it on the car, which, being carried on a solid column of water, does not tend to teeter the car as a free counterbalance does. Gravity tanks are seldom used now. Accumulators are chiefly used with high-pressure plants, but pressures over 250 pounds per square inch are not often met with.

Screw and Ball-Nut Type. — Another type of electric elevator is the screw and ball-nut system, which is a radical departure both electrically and mechanically. It is designed to duplicate hydraulic elevator service in the matter of speed and operation for high-duty service.

The introduction of the two-phase system of alternating current electric power, as well as single and three-phase systems abroad, has produced a demand for elevators that will operate on such systems.

Conveyors. — A conveyor is the simplest conception of a contrivance for carrying material from place to place, and is largely used in the handling of grain, coal and other heavy raw products.

Field for Conveyors.—The demand for facilities for rapidly and cheaply carrying large quantities of raw material in a short space of time has led to the development of a variety of mechanical appliances coming under the general heading of conveyors. These appliances represent a very high degree of engineering ability and mechanical skill, and serve commercial purposes with a speed, safety, exactness and economy which has revolutionized transportation methods at short distances. They are used by railroads, shippers, merchants and transporters of heavy material for short distances, by which industrial operations are greatly facilitated and the conveniences of railroads and handlers of bulky products and raw material are greatly subserved. Large industrial plants have sprung up, especially engaged in the manufacture of these specialties, and a demand has developed in various parts of the world for these valuable devices and expedients. In their mechanism they show a perfect adaptation to the services intended, and they enable economies to be established and time gained which would be impossible were it not for these happy appliances, which seem to have entered upon the industrial arena just at the right time. Cleveland, Ohio, is the center of one of the most successful conveyor-building plants, and the products of this establishment are known throughout the world.

The revolution which has been effected in the handling of bulky products and raw material by these appliances has in no small degree reduced their cost to manufacturers and has greatly facilitated their rapid handling in transportation.

Enameling Process.

Early Enameling.—The art of painting in enamel or with metallic colors, and fixing them by fire, was practiced by the Egyptians and Etruscans on pottery, and it passed from them to the Greeks and Romans. Like most of the arts of which we know anything, it was highly developed among the Chinese ages before Romulus was born or the Roman Empire dreamed of. The early Britons and Saxons understood the art, and it was handed down generation after generation, though the knowledge held by the Huguenot potter, Bernard Palissy, who died in 1589, was lost in his death.

What Enamel Is.—Ordinary commercial enamel is common fused glass with oxide of lead.

Enamel Painting. — Enamel painting upon metal previously glazed is confined to small pieces. The metals used are gold and copper. Silver is never used, as it blisters; and brass is too fusible.

Climax of the Art.—Enameling reached its highest art stage during the twelfth and thirteenth centuries, and since then no one has been able to ascertain the substances of which these or more ancient enamels were composed, or the proportions in which they were employed.

Methods.—The coloring paste which forms the base consists of oxides of lead and tin fused with silex in certain quantities. The colors are mixed with spike, oil of lavender and spirits of turpentine. Highly finished enamels require from fifteen to twenty firings. Enameling on lava is a more recent style of painting.

Other Processes.—Some applications of the enameling processes, so called, are shown on cardboard, leather, photographs, lamps, etc. So-called enameled ware is treated to a mixture of powdered glass, borax and carbonate of soda, fused, cooled and ground. The ware is cleansed with acid, wetted with gum-water, and the powder is dusted on and then fused by heat carefully applied.

Comparative Summary of the Enameling Industry and Production of Enameled Goods in the United States.

	1880	1890	1900
Number of establishments...	2	46	129
Capital invested..............	$295,200	$422,715	$9,184,178
Wage-earners..................	387	508	7,675
Wages paid....................	$98,762	$224,133	$2,259,003
Value of products.............	$504,269	$626,884	$9,798,509

These figures indicate an extraordinary expansion of the industry during the past decade, as measured by increase in number of workers, wages paid and value of product. The rapid creation and distribution of wealth during the past twenty-five years has enabled large numbers of people to gratify their love for decorated ware.

Engineering and Equipment.

Importance of the Engineer.—The science of engineering has attracted the attention of many of the ablest minds in the United States. The engineer is the product of modern civilization as well as the leader and pioneer in it. The conditions of the country, its extent and geographical features and climatic conditions, its rivers and mountains and plains, its immense deposits of minerals and vast forests, in a word, the vast natural resources, all pointed to the coming of a type of man that would be able to develop these resources and open up avenues and create opportunities for the employment of the latent energies of the people.

Nature's Hand.—The engineer addresses himself to conditions and resources. The great work which the engineers have done were mapped out for them by the hand of Nature. The country has been crossed by transcontinental roads, its mountains have been crossed over and tunneled through, its network of rivers and streams have been spanned by bridges, its mineral resources have been developed and utilized. The great West has been opened up through their efforts and opportunities for the employment of labor; skill, capital and enterprise have been developed, which are furnishing opportunities to millions, and which, it might be said, would not have existed but for the engineer.

Bridge Construction.—It would be impossible to classify the work done by the engineer even in one department. In the single matter of bridges there are 1059 different patents covering material and methods of construction, as well as devices for the construction of bridges of the greatest possible strength and long spans. The science of bridge building has been developed to a higher state in America than elsewhere, and American engineering scholars have relaid the foundation principles of bridge construction which the engineers of the entire world have recognized and adopted.

Excavation and Dredging.—In the work of excavation and dredging a very important branch of engineering, 2,708 patents have been issued, covering every possible requirement and condition for the execution of work. In the "dipper" system a number of important improvements have been recently made looking to the better mastery of very hard material and quick movements of the bucket used in the handling of it.

Tunnel Boring.—Machinery for tunnel boring is also of a high order of mechanical excellence and is designed and built with a special reference to the requirements of the particular work to be done. Improved methods of bridge construction and of foundation building for bridges, and for the construction of bridges, have been introduced, which are a surprise to European engineers. American bridge engineers have been called from various parts of the world to build bridges, which they have done in shorter time and with better satisfaction than has been found possible in the best engineering establishments of Europe. The St. Louis bridge and other bridges across the Mississippi, the Niagara and Poughkeepsie bridges, and the wonderful structures in New York City, are evidences of the towering civil engineering genius of the American civil engineering profession.

Comparison of Brooklyn Bridges.—An excellent view of bridge building progress may be had by comparing the two immense structures which now unite the boroughs of Manhattan and Brooklyn.

THE OLD BROOKLYN BRIDGE.

Dedicated and opened to travel, May 24th, 1883.

Time of construction, 13 years.
Cost, $21,000,000.
Length, exclusive of approaches, 5,980 feet.
Actual width, 85 feet.
One deck, net width, 73 feet.
Number of wires in each cable, 5,296.
Miles of wire in four cables, 14,361.
Diameter of cables, 15⅝ inches.
Strength of each cable in tons, 12,200.
Height of towers above roadway, 159 feet.
One promenade, 2 trolley tracks.

Two roadways, 2 railroad tracks.

Sustaining power, 2,000 pounds per running foot.

River, or main span, 1,595 feet 6 inches.

THE NEW BROOKLYN OR WILLIAMSBURG BRIDGE.

Dedicated December 19th, 1903.
Time of construction, 5 years.
Cost, estimated, $12,000,000.
Length, exclusive of approaches, 7,264 feet.
Actual width, 118 feet.
Two decks, net width, 137 feet.
Number of wires in each cable, 7,700.
Miles of wire in four cables, 17,432.
Diameter of cables, 18⅝ inches.
Strength of each cable, in tons, 24,500.
Height of towers above roadway, 210 feet.
Two promenades, 4 trolley tracks and 2 bicycle tracks.
Two roadways, 2 railroad tracks.
Sustaining power, 5,000 pounds per running foot.
River, or main span, 1,600 feet, the longest in the world.

Such was the difference in engineering facilities in less than twenty years, that the larger structure of 1903 was completed in less than half the time of that of 1883, and at four sevenths of the expense.

Hydraulic Dredging.—In dredging by the hydraulic system important processes have been introduced for the quick disintegrating of the material by a cutter and pumping it up in suspension in water and forcing it through pipes to a distant point of discharge. A system known as the Bowers system, which is used by the government, has been applied in battery fashion, by which a vastly increased amount of work can be done. The system of dredging by clam shell dredges has been improved by the direct application of fluid pressure to close the bucket.

Excavation of Clays.—Inventions for the excavation of clay and for the piling and burning of it in a crude state for ballast for railways have been introduced and are in use on various railways. The dressing of railroad beds by machinery mounted on the worktrain has also been brought up to a high point of efficiency.

Freezing Process.—The freezing of sand, a novel method for overcoming peculiar difficulties, has been established and has done excellent service. Shafts are sunk through quicksands in this way, which would be otherwise impossible of penetration. Improvements have been made in wheeled scoops for excavating and removing earth in great quantities, and new machines have been introduced for finishing and repairing roads.

Sewer Construction.—Improvements have also been made in deep sewer construction by which the minimum of obstruction to the street is effected. Balance locks for canals have been perfected and are receiving worldwide attention. They are intended to provide ease and rapidity of action. The pneumatic caisson of Edes and Flad are examples of the highest advance in art in this direction. The "bear-trap" canal lock gate is a signal advance over all previous lock gates. Haupt's dike or jetty is also a wonderful triumph of engineering genius, and Alenwood's hydraulic giant for washing down gold-bearing hills is revolutionary in its efficiency.

Steam pile-drivers of remarkable power are in use in harbor work which represent the high-water mark of inventive skill in that direction.

The mere enumeration of the greater achievements of civil engineering, and the naming of a scattering few of the valuable appliances invented and adopted for the economic prosecution of work, in no way conveys an understanding of the remarkable accomplishments in this field during the past century. No problem is too great or difficult to the engineer; whether it is in harnessing Niagara, or tunneling mountains, or erecting great industrial plants, or spanning wide rivers with structures of wire and steel, the engineer is equally at home.

Some twenty engineering schools are sustained, wherein young men are taught the theory and practice of civil engineering under the guidance of experts.

Engraver's Art, The.

Historic Review.—A review of engraving as it was thirty years ago and to-day represents a most wonderful advance in one of the most useful arts of the age. With the half-tone process and various processes of to-day for reproduction work the engravers of late years have worked a revolution which has no similar counterpart in any branch or division of art. The commercial importance and value of these modern methods of reproduction is beyond computation. They have made available to popular use a vast quantity of material which, but for them, would have remained beyond the reach of the masses. These processes are familiar to the average reader, and are of too recent creation to call for detailed description. They represent in one sense the invasion of mechanism into the domain of art. Their warrant and justification are the great utilities subserved, the great good done, and the educational influences set into action.

Classification of Work.—It is with the engraver *per se* that we are now concerned. The several branches of engraving prior to the present expansion of the engravers' art may be classified as line engraving on metal plates, in which the line is always encased; etching, in which the lines are corroded; and mezzotint, in which there are no lines whatever, but only shades produced, by roughening the surface of the metal, and the wood cut, in which the lines which print black are in relief.

Wood Engraving.—Wood engraving dates back to the beginning of the fifteenth century. The earliest work was known as cribli, which meant riddling with small holes. Engraving on copper and steel is the converse of wood engraving. Line engraving received, in the past century, both an impulse and a check. The impulse came from the growth of wealth and the check from the demand for cheaper and more rapid methods. Pure line engraving is still practiced in a limited way. In France, lovers of line engraving have organized themselves into an association for its preservation.

Etching and Line Engraving.—The chief difference between etching and line engraving is that in line engraving the furrow is produced by the plowing of the tool, while in etching the copper is eaten away by the acid. The English word is simply, as anglicized, a form of the Dutch etzen (eat). This word is sometimes erroneously used for pen drawing. Etching has been most practiced in France and Holland, and to a lesser extent in Italy, Germany and England. It received a powerful impulse from celebrated painters.

Etching Subordinated to Painting.—Something of a revival in etching set in some thirty to fifty years ago as an independent art in Europe, but commercial requirements have made modern etching almost entirely the slave of painting. Nearly all the clever etchers of the present day are occupied in translating pictures, and much of this work is deserving of high commendation. The comparative rapidity of the process and the ease with which it imitates the manner of painters, have caused etching to be now very generally preferred to line engraving by publishers for the translation of all pictures excepting those belonging to a severe and classical style of art. Yet, notwithstanding the present commercial predominance of etching from pictures, there is still a galaxy of eminent men who have cultivated original etching with success. Etching clubs or associations of artists for the publication of original etchings have been founded in various countries in Europe. The real difficulty of the art and its apparent facility have led to much worthless production.

Three Styles of Etching.—There are three styles of etching: (1) Pure line. In line etching, as in line engraving, the great masters purposely exhibit the line, and do not hide it under too much shading. (2) Line and shade. The most important lines are first drawn throughout, and the shade thrown over them like a wash with a brush over a pen sketch in indelible ink. (3) Shade and texture. This is used principally to imitate oil painting. Here the line is entirely abandoned, and the attention of the etcher is given to the texture. He uses lines, of course, to express these, but does not exhibit them for their own beauty; on the contrary, he conceals them.

Analysis of Styles. — The first of these three styles is technically the easiest, the next more difficult and the third most difficult. It is often asserted that any one can etch who can draw, but this is an error. The artist does not see his work as he proceeds. The mistakes in the "biting," which are committed by the inexperienced, often destroy all the relations of tone.

The Aquatint.—The aquatint successfully imitates washes with a brush. Aquatint may be successfully used in combination with line etching in which the line imitates that of the lead pencil. The natural tendency of these three kinds of engraving is from line to shade and from shade to texture. Line is a separate study. Shade is its enemy. When texture becomes an object, the line is lost altogether. This appears to be the law of development in the graphic arts. It is an approach to nature, which is all shade and texture without line. The pure line is a loss in art from its ready expression of the paling of the artist.

Mezzotint.—Mezzotint comes nearest nature. It is said to have been invented by Prince Rupert or Louis Siegin about the year 1611. The plate, in being prepared, is gone over about eighty times in different directions by an instrument with 100 or 120 small teeth. It then presents a fine, soft-looking and perfectly even grain. The engraver works from dark to light by removing the grain with a scraper, and in so doing the tint becomes paler and paler. Pure white is got by scraping the grain away entirely. More than one hundred engravers in mezzotint employed themselves on the portraits of Sir Joshua Reynolds, and the best of them are valued as classics of the art. Dry point is really nothing but mezzotint in line. As the point of the stylus makes its scratch on the copper it raises a bur, which retains the ink in the printing, just as the bur from the cradle does in the mezzotint.

Materials Used.—Copper, steel and zinc are the metals chiefly used for engraving. Copper is preferred, as it is covered with a coat of steel by the electrotype process, which enables it to resist printing indefinitely, as the steel can be removed at will. Zinc is similarly coated with copper.

Materials and Methods.—Two methods are followed in preparing a lithographic stone. In one the stone is covered with a gum and ink-resisting compound, dried, and the design scratched through the ground; in the other, the stone is etched through a ground of asphaltum, when acid is applied to deepen the lines, which are inked, cleaned, gummed and then etched.

Historic Sketch.—The art of cutting into stone or metal is very ancient, as is demonstrated in all the olden countries. Engraving on metal originated with chasers and inlayers, but the thought of printing from the plates thus engraved did not suggest itself. The value of plate engraving as a means of printing was discovered in 1440. Aquatint engraving originated in 1662. Jacob Perkins, of Philadelphia, in 1819 invented engraving in steel. Wood engraving originated in cutting of blocks to print playing-cards, and by 1440 engraving on wood had reached the dimensions of an art.

Decrease of Wood Engraving.—Wood engraving is largely supplanted by the process methods of recent years. The half-tone process, of comparatively recent introduction, further revolutionized former methods and helped to greatly expand the opportunities for commercial success.

Steel Plates.—No better comprehension of the growth of engraving can be had than by noting the figures which record its growth. The number of steel and plate-printing establishments increased from 55 in 1880 to 134 in 1890 and 286 in 1900. The value of these products increased from $2,998,616 in 1880 to $3,347,804 in 1890 and $5,068,558 in 1900. The number of workmen engaged increased from 1,916 in 1880 to 2,296 in 1890 and 3,299 in 1900.

The growing demand for costly publications and for illustrated work has greatly stimulated the art of engraving, especially along the line of trade requirements, catalogues and commercial and literary publications of rapidly increasing variety and volume.

Envelope Making.

A Recent Invention.—The envelope of to-day is of recent production. Not many years ago letters were sent without envelopes, and it was the custom to fold them in a peculiar way and secure the folded edges with wax. The appearance of the receptacle for letters was gladly welcomed, especially by the commercial interests, and in a very short time the use of envelopes became general. The letter envelope suggested envelopes of larger size and also led to the suggestion of paper bags for a great variety of purposes.

Special Machinery.—It has only been within comparatively recent years that envelope making developed into a special industry. This was brought about by the invention of special machines for the rapid manufacture of envelopes, and through these machines advantages were obtained which enabled specially-equipped manufacturers to undersell all who attempted to make envelopes in the old way.

Plants and Prices.—The model envelope manufacture presents evidences of extraordinary skill, and with the appliances used, the price of envelopes has naturally declined with their greater use. The industry has broadened, embracing within its folds various side branches for the sake of the economies gained by control over all elements of the industry.

Comparative Summary of the Envelope Industry.

	1880	1890	1900
Number of establishments ..	12	41	51
Capital invested	$923,800	$3,218,466	$5,612,509
Wage-earners................	1,204	2,325	2,984
Wages paid.......	$344,143	$812,544	$1,150,463
Value of products	$3,000,617	$4,855,680	$6,299,330

Explosives, Manufacture of.

Growth of Industry.—The number of establishments in the United States manufacturing explosives increased from 54 in 1880, employing capital represented by $6,585,185, employing 1,340 men, producing $5,802,029 worth of products, to 97 in 1900, with a capital of $19,465,846, employing 4,502 men and producing values worth $17,000,000. The industry was thus approximately trebled in two decades.

Gunpowder.—The manufacture of gunpowder is very old, it having been used in the battle of Crecy, in 1336. The modern methods of manufacture in the United States began at Wilmington, Del., in 1802, by Du Pont de Nemours. A recent improvement consists in the introduction of retorts for the burning of charcoal and the manufacture of saltpetre by conversion, and in the devising of various forms of press mills. The manufacture of potassium nitrate was adopted in the Du Pont works in 1868.

Blasting Powder.—In the manufacture of blasting powder the expensive potassium nitrate, known as "India saltpetre," has been replaced by cheap sodium nitrate, known as "Chile saltpetre." Immense deposits of this material have been developed. The ingredients for blasting powder vary widely. The average composition is 74 per cent. sodium nitrate, 16 per cent. charcoal and 10 per cent. sulphur.

Nitro-glycerine.—The number of establishments manufacturing nitro-glycerine increased from 3 in 1870 to 19 in 1880 and 22 in 1900. This product was discovered in Italy in 1847, and its commercial manufacture was entered upon in 1862 by Alfred Nobel in Sweden. In 1863 he discovered that nitro-glycerine could not only be exploded with certainty by means of a copper capsule containing mercuric fulminate, but that the power developed was enormously greater than could be obtained by any other means. This marked an epoch in the history of nitro-glycerine. It is manufactured by mixing glycerine with a mixture of nitric acid and sulphuric acid. Its principal use is in making dynamite and blasting-gelatine.

Gun-Cotton.—In 1900 there were ten establishments manufacturing cellulose nitrates, of which gun-cotton is one form. Cellulose is some multiple of 6 parts of carbon, 10 parts hydrogen and 5 parts oxygen. The cellulose nitrates are prepared by immersing purified cotton in mixtures of nitric and sulphuric acid. In making gun cotton the acid mixture consists of 1 part by weight of nitric acid of 1.5 specific gravity to 3 parts by weight of sulphuric acid of 1.845 specific gravity, and 1 pound of steam-dried cotton immersed in and digested for 24 hours with 12 pounds of this acid mixture. The acid is then wrung out, and the gun-cotton is pulped, washed and compressed into blocks for use.

Gun-cotton is used in military mines and torpedoes, and for destructive purposes generally.

Dynamite.—In 1900 there were thirty-one different establishments manufacturing dynamite, employing $7,551,121 of capital and 1,758 wage earners. Dynamite was invented by Alfred Nobel in 1866. In 1875 he invented an explosive made by dissolving soluble cellulose nitrate in nitroglycerine into a jelly-like mass known as blasting gelatine. It is often mixed with wood meal or wood pulp, producing gelatine dynamite.

Smokeless Powder.—Smokeless powder was manufactured in an experimental way in Philadelphia in 1850, by Charles Lennig. The next attempt was started in 1870 at Quincy, Mass. The first factory erected for the commercial manufacture of smokeless powder, and operated at Newport, R. I., was in 1889-90. Earlier attempts were made to produce smokeless powder, dating as far back as 1800. In 1898 the government adopted a cellulose powder, the nitro-cellulose containing 12.45 per cent. of nitrogen.

Defensive Uses.—The development of the science of manufacturing explosives has revolutionized the methods of attack and defense among the nations of the world. Naturally the methods and results are kept secret as much as possible, each government seeking to obtain some advantage over others in materials used and in the methods of use. The manufacture of small arms, as well as heavy ordnance, has been greatly stimulated, and the efficiency of arms has been vastly increased, especially in the distances at which destructive work can be effected.

A New Explosive.—A late report from our consul-general at Frankfort, Germany, announces that the latest explosive is made of powdered aluminum mixed with nitrate of ammonia, and which has recently been put upon the market under the name of "ammonial." This explosive is said to be one of the safest and surest known, as it cannot be exploded by friction or blow, while otherwise containing all requisites of an explosive. The fact that aluminum is not affected by nitric acid gives the important property to ammonial of not being subject to disintegration, as it is not affected by frost; accidents which so often occur when thawing out frozen dynamite are not to be feared. It is not affected by moisture, and the explosion is caused by an ordinary cap.

Explosives in the Industries.—The use of explosives in the industries has become a permanent and most important feature. They are used in coal mining, oil boring, quarry blasting and blasting out obstructions, also in marine work and in numerous other directions where material is to be broken or removed. They are occasionally used to arrest progress of serious conflagrations. The economic advantages of explosives have been well attested, and in their judicious and supervised use engineering and industrial operations are much simplified.

Comparative Summary of the Industry.

	1880	1890	1900
Number of establishments ..	54	69	97
Capital invested	$6,585,185	$13,539,478	$19,645,846
Wage-earners	1,340	2,353	4,502
Wages paid	$675,414	$1,240,502	$2,383,756
Value of products	$5,802,029	$11,352,615	$17,125,418

Fertilizers, The Making of.

Sources of Supply.—The fertilizer industry has, within the past decade especially, assumed enormous proportions, because of the extraordinary demand for fertilizing material to meet the rapidly growing agricultural requirements. The great bulk of fertilizing material comes from Tennessee, Georgia, South Carolina and Florida. The deposits of material in these States from which fertilizer supplies are obtained cover large sections, and they are being actively worked by the aid of mechanical appliances which greatly increase the production and minimize cost. The decline in the cost of fertilizing material has been remarkable, because of the application of mechanical and chemical methods of great ingenuity to economically and rapidly handle the material.

The Menhaden Industry.—The menhaden industry furnishes a large supply of fertilizing material by the securing of supplies of menhaden fish along the Atlantic coast. Owing to the vigor with which the menhaden fish is sought, the supply is gradually declining, having fallen off from 79 factories in 1880 to 25 in 1900. In the first-mentioned year 366 sailing vessels and 82 steamers were engaged in the industry, employing 3,261 men, catching that year 776,000,000 fish, from which were produced 2,035,000 gallons of oil and 19,195 tons of scrap. The production of oil from that source in 1900 was about one-half that of 1880.

Phosphoric Acid.—The importance of phosphoric acid was early recognized in fertilizing. The manufacture of chemical fertilizers in the United States began about 1850. In 1855 Peruvian guano was largely used, but was found too stimulating and deficient in plant food. This source of supply was soon practically exhausted. Much fertilizing material is obtained from phosphate rock, or bones treated with sulphuric acid, by which superphosphate, or acid phosphate, is formed, with which is mixed ammoniates or potash, or both, thus producing various grades of ammoniate superphosphate, superphosphates with potash, or complete fertilizer. The total amount of superphosphate produced in 1900 was 1,480,414 tons, which is made by mixing equal weights of phosphates and sulphuric acid. Florida rock contains up to 80 per cent. or more of phosphate, which is mainly shipped abroad to supply the foreign demand, while our manufacturers mainly use that from South Carolina, Florida and Tennessee. The manufacture of phosphate is a simple process and satisfactory, although its percentage of soluble phosphoric acid ranges from 20 to 24 per cent., as compared with concentrated phosphate or "double super," which sometimes contains as much as 47 per cent.

Slag Phosphate.—The use of slag phosphate, which some years ago was quite general, has almost completely ceased in the United States, while its use is continually extending in Europe.

Stock - Yard Fertilizer.—The materials from which this fertilizer is made is chiefly derived from the rendering and cooking tanks. After being thoroughly cooked it is passed through a drying press, to reduce the water contained and secure any grease possible, which adds nothing to the fertilizing properties. The drying presses are usually square boxes, about 16 inches long, 12 inches wide and 3 inches deep, and operated either by hydraulic power or by a screw press. After rapid drying at a temperature of 260 degrees Fahr., in which machines of various kinds are used, the product is put in bags and shipped to manufacturers of fertilizer compounds.

Future Source of Fertilizing Material.—The gradual but ultimately inevitable exhaustion of the nitrate deposits of South America lends a growing interest to the methods which have been devised for obtaining a supply of nitrogen for fertilizing purposes from the inexhaustible storehouse of the air.

Calcium Cyanide.—Dr. Earlwein, of Berlin, Germany, according to a quite recent consular report, has brought the nitrogen of the air into combination with a mixture of powdered charcoal and lime in an electric furnace. The product of this combination is a black substance containing, besides the lime and carbon, 10 to 15 per cent. of nitrogen in perfect condition to be used as a fertilizer. From the experiments thus far made with this new artificial nitrate, which is known in commerce as calcium cyanide, it appears that its nitrogen acts upon plants quite as effectively as the Chile saltpetre. Scientists who have examined this process are confident that the problem of obtaining nitrogen for fertilizing purposes from the atmosphere is satisfactorily solved. It is also stated that works are being erected at Niagara Falls to derive the free nitrogen from the atmosphere, with the aid of electricity, forming nitric acid and producing nitrate of soda. The next point to be determined is whether the process can be conducted on a large scale and at a cost which will make it economically available for general agricultural purposes.

Comparative Summary of the Fertilizing Industry.

	1880	1890	1900
Number of establishments ..	364	390	422
Capital invested............	$17,913,660	$40,594,168	$60,685,753
Wage-earners	8,598	9,026	11,581
Wages paid..................	$2,648,422	$3,417,870	$4,185,289
Value of products...........	$23,650,795	$39,180,844	$44,657,385

Fire Engines.

Early Fire-Extinguishing Devices.—Fire-extinguishing devices were used by the Romans and during the time of the Emperor Trajan, which were leather bags to which pipes were attached and from which water was expelled by hand-pressure. Engines were also used, or what passed as engines, during the Middle Ages, although the term "fire engine" was a misnomer, as steam was not used and not known. Fire-extinguishing appliances were regularly made in England in 1734. As early as 1731 American mechanics had devised and successfully introduced appliances which were useful in checking the spread of fire.

Leather Valves Introduced.—Metallic valves were used, and were not superseded until fifty years later, when leather valves were introduced. For a long time rotary and semi-rotary pumps were adopted and these were succeeded by various improvements. The first fire engine operated by steam was made by Braithwaite, in 1830, in England. John Ericsson, on this side, produced a good fire engine, but it did not attain commercial importance.

First American Steam Fire Engine.—The first practically successful steam fire engine was made in 1850 by A. B. Latta, of Cincinnati, Ohio. It was in that city that the first steam fire department was organized. Other cities quickly followed and in a few years steam fire departments were organized in all the larger cities. American ingenuity addressed itself to the problem of building fire engines with success. In 1872 self-propelled fire engines appeared on the streets of nearly all cities, and between that year and 1900 engines were made under twenty different patents.

Chief Parts of an Engine.—The main parts of a steam fire engine are the boiler, engines, pumps and the vehicle upon which it rests. The engines and pumps are usually vertical and double-acting and in duplicate. A few are built horizontally. The rated capacity ranges from 400 gallons to 1,300 gallons per minute and the weight of engine is from 10,000 to 20,000 pounds; the extreme height is usually 10 feet; length, 16½ feet; width, 7¼ feet; propelled by power from the main crank shaft through two chains running over sprocket wheels on the main rear wheels. There are, however, various other and later forms of construction showing highly-developed mechanical skill.

Capacity. — The best makes have two sets of pumps and deliver 3,000 gallons and upward per minute under a pump pressure of 180 pounds per square inch and upward. By removing a key the road-driving mechanism is disconnected and the power goes to the pumps. The best fire-boats have two sets of vertical expansion pumping engines, with 14-inch steam and 8-inch water cylinders, 11-inch stroke, with a combined capacity of 6,000 gallons per minute. Besides steam, gasoline engines are sometimes used for driving pumps of portable engines.

Chemical Fire Engines.—Chemical fire engines and extinguishers range from hand-force pumps to engines on wheels. The larger include a generating tank or tanks in which water and soda are placed, with an agitator to aid in dissolving the soda, the acid-feeding chamber and the necessary hose. When the generating apparatus is in duplicate with proper hose attachments, continuous streams may be thrown. The water serves as a medium to carry the gas and the gas is the motive power for the water. Smaller quantities of water are required as compared with fire engines. These engines are particularly useful to cope with incipient fires.

The introduction of chemical fire extinguishers makes slow progress, notwithstanding their recognized efficiency in the extinguishment of fires. They are used to a limited extent in all cities and towns, and are found to be a valuable complement to the steam fire engine. At present there are only 17 establishments engaged in their manufacture, and the value of engines turned out in 1900 was $217,883.

Fire-Extinguishing Apparatus. — Fire-extinguishing apparatus is used to force water charged with some gas on a fire in which carbonic acid gas is generally used. It consists usually of a convenient reservoir of water in which are two small vessels, one containing some carbonate and the other a small acid. When used, the contents of the smaller vessels are emptied into the water, the carbon dioxide liberated from the carbonate of the acid, is then partly taken up by the water and the pressure created by the confined gas, which forces out the solution in a strong jet when the vessel is opened.

Babcock Fire Extinguisher.—The Babcock fire extinguisher is a cylindrical vessel filled with a solution of sodium bicarbonate over which is suspended a vessel containing sulphuric acid, which is made to tilt over and discharge its contents into the solution when brought into use, thus liberating the carbon dioxide. Large cylinders containing chemical salts, mounted on wheels, are known as "chemical fire engines."

Fireworks, Manufacture of.

Extent and Uses.—The number of establishments engaged in the manufacture of fireworks increased from 39 in 1880, employing 735 workmen and producing $1,391,132 worth of material, to 46 in 1900, employing 1,638 workmen, whose product was valued at $1,785,271. The major portion of these products are used in connection with the celebration of the natal holiday, the Fourth of July. The use of harmless explosives by the youth of the land has become a fixed custom which is encouraged by public sentiment. This youthful indulgence in mimic pseudo warfare is approved as a means of reminding the young of the Revolutionary struggle for political independence from Great Britain.

Flags and Banners.

Uses of Flags.—The earliest defensive gatherings of men were signalized by flags which served to indicate the country or locality from whence they came or the leader they served. Each people or nation adopted a flag of special design, color or peculiarity as an emblem of separate nationality. Flags of nationality are standards, ensigns and pennants. Flags of occupation indicate service, as war, merchant, dispatch, pilot, yacht squadron, liners, etc. Flags of intelligence are of various colors and of three shapes—square, pointed and burgee. They are used in various combinations to transmit messages according to a secret code. Each of the countries of Europe and Asia and the republics of America has its national standard, bearing a device, usually of historical significance and appealing to the national pride.

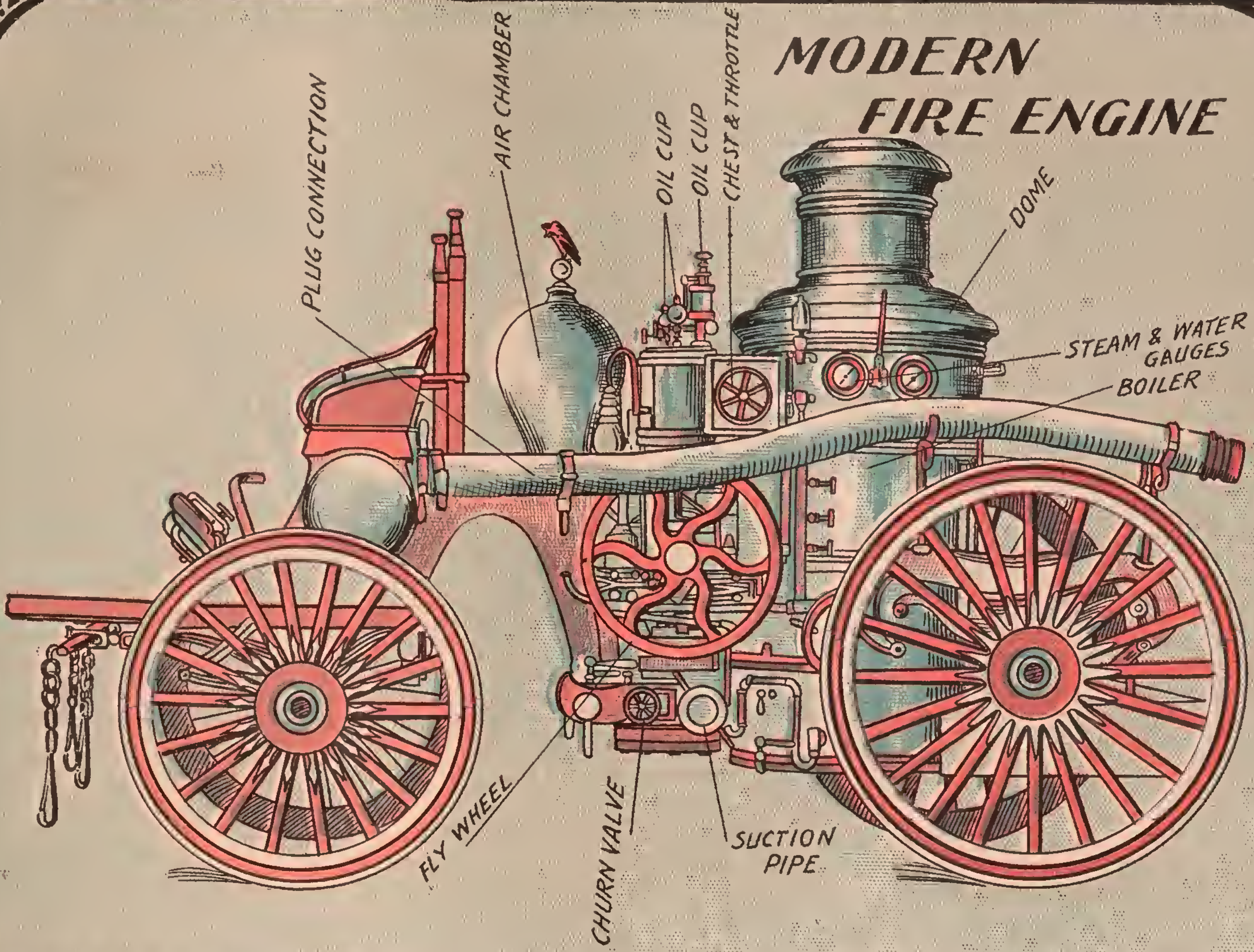
Manufacture of Flags.—There are 36 establishments in the United States which make flags, employing between 500 and 600 workmen, producing goods which in 1900 were worth over one million dollars. The use of flags is evidently increasing, as the value of the flag factory products in 1890 was $455,849, and in 1880, $119,600.

Colonial Flags.—The earliest colonial flag was a white field with a large St. George's cross, with the initials J. R., standing for James, King, surmounted by a crown. After the Battle of Lexington the Connecticut Volunteers placed on their flag "qui transtulit sustinet" (He who brought us over sustains us). The flag of New Amsterdam, or New York's first name, was a beaver, representing the fur industry. This was typical of New York in its commercial instincts. It was a flag of commerce rather than a flag of patriotism. The earliest vessels which sailed from American ports carried a flag showing a pine tree. Privateer flags, which were not few in number in those days, showed a mailed hand grasping thirteen arrows.

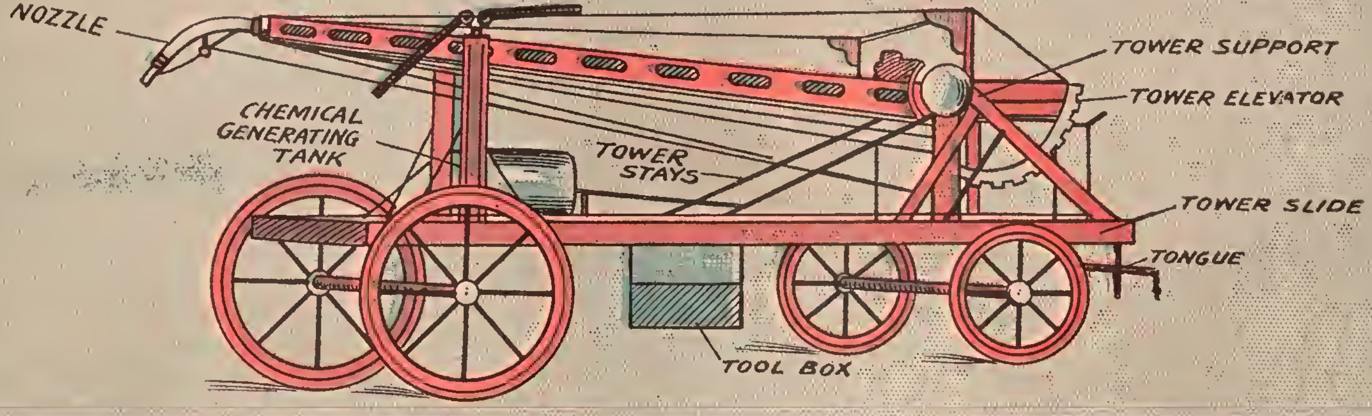
Revolutionary War Flags.—The first flag used in the Southern States was blue with a white crescent, with the words "Liberty or Death." At Cambridge, Mass., General Washington displayed a flag on September 2, 1775, which was blue with white-ground crescent and which was devised by Franklin, Lynch and Harrison, and contained thirteen stripes of red and white with the Union Jack in place of the stars. The Rattlesnake flag was often seen and showed thirteen rattles on the coiled snake.

Origin of the American Flag. — On June 14, 1777, the Continental Congress enacted that the flag of the United States should consist of thirteen stripes alternately white and red; that the Union be designated with thirteen stars, white on a blue ground. Paul Jones raised the first flag at Fort Stanwick, near Rome, N. Y., and the first flag was carried in battle at the Battle of Brandywine, near Philadelphia, September 11, 1777, and was carried in all battles and marches after.

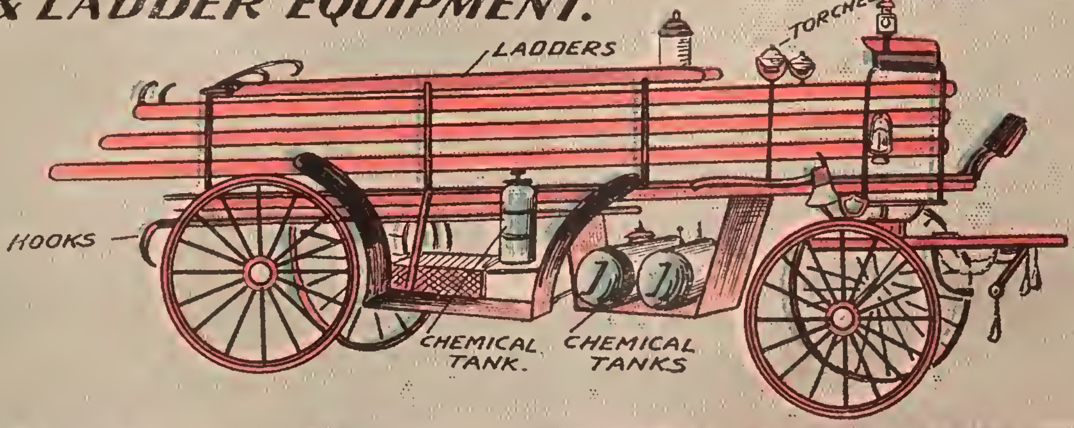
MODERN FIRE ENGINE



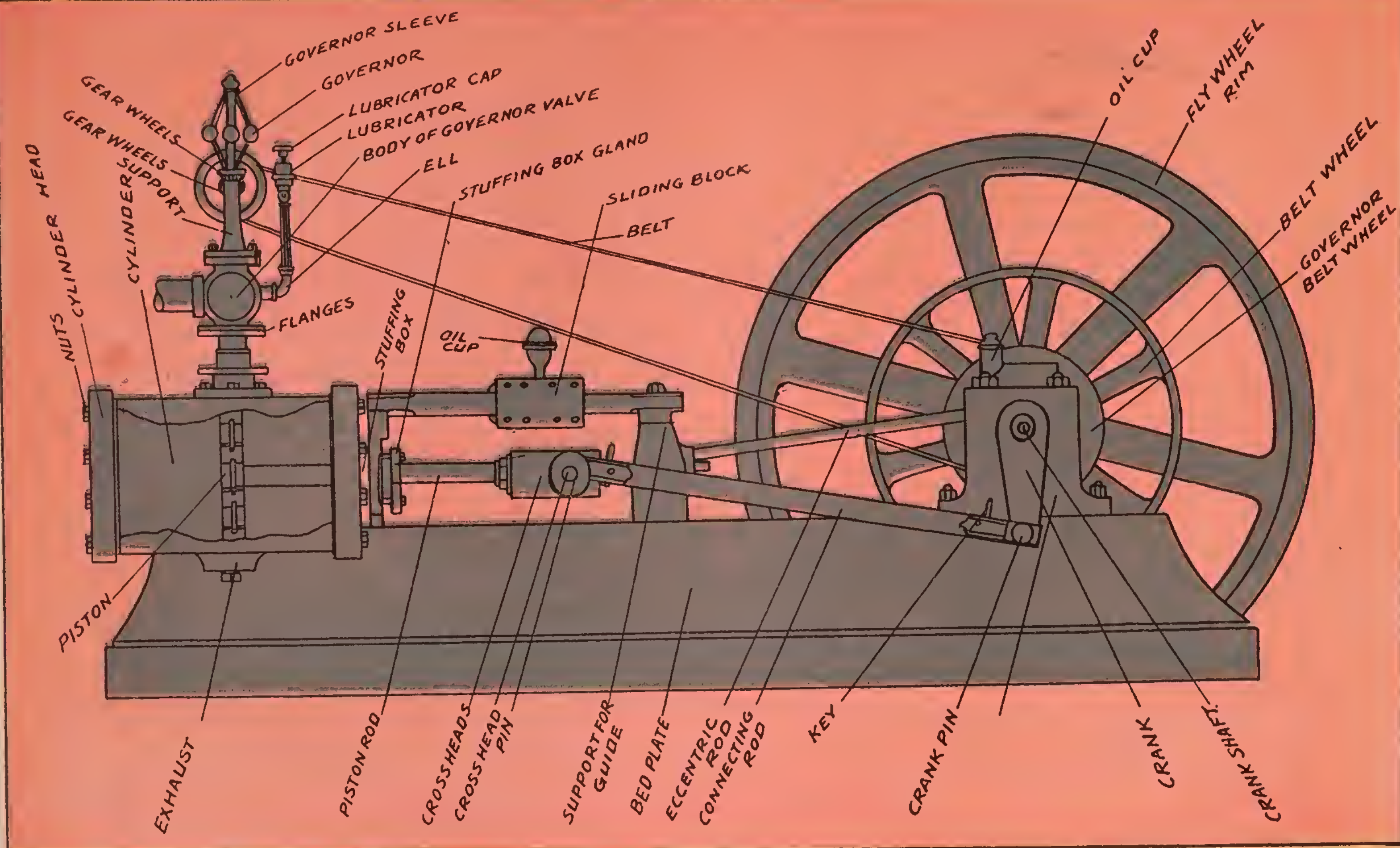
WATER TOWER



HOOK & LADDER EQUIPMENT.



A STATIONARY ENGINE.



CHRONOLOGY OF ELECTRIC PROGRESS:-

Electric Current Discovered by Allesardro Volta	1800
Arc Light Produced by Sir Humphrey Davy	1810
Induction discovered by Faraday	1831
First Electric Road built by Thomas Davenport of Brandon, Vt	1835
Automobile invented by Davenport	1835
Wheatstone and Cooke system of Telegraphy invented	1835
Zinc Copper battery invented by Daniell	1836
Submarine Cable laid across Hoogly River	1839
First Morse Telegraph Line Constructed	1844
Printing Telegraph System invented by Royal House	1846
Automatic Repeaters invented	1848
First long Submarine Cable laid in British Channel	1850
First successful Atlantic Cable laid	1858
Electrolytic Copper Refining invented by James Elkington	1865
Stearns Duplex Telegraph System introduced	1872
Edison's Quadruplex System introduced	1874
First Modern Electric Road built by Geo. F. Greene of Kalamazoo. Mich.	1875
Telephone invented by Bell & Gray	1875
Continuous Current Dynamo discovered by Gramme	1876
First Telephone Exchange operated at New Haven, Conn.	1878
Incandescent lamp invented by Edison	1879
First Central Lighting Station established in Pearl St. New York	1880
Storage Battery or Accumulator invented by Plante	1882
First Practical Trolley Line built by J. C. Henry in Kansas City	1884
First European Electric Roads built in Berlin by Siemens Bros.	1884
Electricity first used on Elevated Roads in New York	1885
First long distance High-voltage power transmission plant installed at Pomona, Cal.	1892
Telautograph invented by Elisha Gray	1893
Heavy Trains moved by Electric Locomotives in Baltimore	1895
X Ray discovered by Dr. Wilhelm Konrad Roentgen	1895
Wireless Telegraphy in practical operation by Marconi	1896
Road Automobiles come into general use	1897
Trans-Atlantic Telephony made possible by Dr. M. I. Pupin	1900
Improved Storage battery for Automobiles invented by Edison	1901

Soon after the resolution of Congress, which determined the design of the American flag, General Washington, with two others, visited Elizabeth (Betsy) Ross, then living on Arch street, Philadelphia, about three blocks from Independence Hall, and engaged her services to make a flag in accordance with the design ordered. Betsy Ross did so, and this flag became the pattern from which all other flags were made. The home of Betsy Ross still stands as it stood then and a patriotic association proposes to secure it and preserve it as one of the historic spots connected with the Revolutionary struggle.

Special Flags.—Certain officials of the United States have flags to designate their position and authority. The flags of flag officers of the United States navy are blue carrying white stars, four for an admiral and two for a rear admiral. The flag of the Secretary of War is of scarlet bunting bearing upon it an eagle with outstretched wings.

Salutation.—Saluting the flag consists in lifting it three times and then hauling it down. In the navy, when the flag is hoisted at "colors" or hauled down at sunset, all officers and men salute it, and all patriotic Americans uncover when it is unfurled on public occasions.

Flour Making—Grist Mill Industry.

Early Flour Making.—It is probable that before the dawn of history, while man was in a savage or semi-savage state, the rudiments of agriculture were practiced and the cultivation of cereals among the first efforts of the people. Flour was for ages made by extremely primitive processes. The first successful flour mill erected was in London in 1784, where millstones were used for grinding.

Mortar and Pestle.—Cereals were first eaten raw and without any preparation whatever. It was no doubt discovered that by the action of fire the flavors became more agreeable and easy of mastication. The first effort at grinding, and which still prevails in some parts of the world, consisted in simply breaking the cereals into coarse fragments. This developed into the mortar and pestle method of grinding, which still prevails in isolated localities. Grain consists of three important constituents—the hull, the germ and the matter intervening between them, consisting chiefly of starch and protein.

Three Types of Grinders.—The first type is the mortar and pestle; second, machines for crushing, which may be either of stone or hardened steel; the third system is the roller system of milling, in which the grains are disintegrated and reduced to successive stages of sub-division by passing through rolls smooth or corrugated, in which, from one series to another, there is an increasing approximation of the surfaces. The rolls may revolve at the same peripheral rate, or the speed of rotation of the rolls may be different, thus securing a grinding or tearing process and the mashing or disintegrating impact of the rolls themselves. The third method is now almost universally employed.

Bolting Cloths.—In the grinding of cereals the different parts of each grain break up into fragments, which may be classified into large and small, of different shape and size. The starch and protein matter are usually spherical, while the hulls and germs are usually flattened. In order to separate these two sizes, bolting cloths are used which permit the fine, starchy particles and the protein particles to pass through, the others being retained. Hence, the products of grinding are divided into three classes—the bran or outer hull and middlings and flour.

High-Grade Flour.—Wheat may be good, bad or indifferent, according to its freedom from dirt, husks and other impurities. The first step in the milling of wheat is to remove these foreign substances, as far as possible, by friction, winnowing and other means. Blasts of air are used and the purified wheat is then subjected to a series of operations, which consist in breaking the grain into successive portions. These portions differ in shape and composition.

Since 1870 the roller mill has taken the place of the disk mill or burr; the middlings purifier next appeared, which was a flat bolt or shaker through which passed an upward draft of air, lifting the bran specks and fuzz from the shaken material. The dust collector was next introduced, which collected the fine flour dust, which had frequently produced explosions. The principle of these collectors is a vertical or rotary current which masses and precipitates fine particles which no filter, however fine, can stop.

Value of Flour and Corn.—The total quantity of flour used in the grist mill industry in the United States during the census year was 489,914,004 bushels, worth $317,913,277; the Indian corn used amounted to 241,029,249 bushels, worth $93,892,609. Much of the Indian corn is used as feed for cattle.

Custom Mills and Grist Mills.—There is a marked distinction between merchant and custom mills. Custom mills, in a broad sense, are those grinding wheat, corn, rye and other grain furnished from farms in the neighborhood, and are usually termed "grist mills." Merchant mills are large manufacturing establishments supplying the home market and exporting flour to the principal foreign countries.

Growth of the Industry.—The most rapid increase in the number of establishments was in the period from 1860 to 1870; the milling industry, like every other, illustrates the well-established fact that greater economy in manufacture can be secured in a small number of large mills than in a large number of small mills. The capital invested in 1900 shows an increase of only 5 per cent. over that of 1890; the number of wage earners in 1900 diminished, owing principally to improved processes in handling the grain and products. While the price of cereals declined during the past decade the total amount paid for raw material increased 9.6 per cent. because of the greater quantity used.

Number of Mills.—The largest number of small mills is found in Pennsylvania, and mills of the greatest capacity in Minnesota. Minnesota ranks first in everything excepting the number of establishments. New York ranks second with capital invested, wage earners, wages paid and value of products. Ohio comes third. The Minneapolis output was 14.1 per cent. of the total, New York 7.6 per cent., Ohio 6.7 per cent. Of the total value of cereal products in 1900, wheat flour constituted 62.1 per cent. compared with 68.3 per cent in 1890. The ratio of corn meal was about the same as to value. In quantity, wheat flour increased during the decade 26.7 per cent., and cornmeal 8.5 per cent.

In 1815 a flour mill was erected in Cincinnati, Ohio, with a capacity of 700 barrels per week. The first merchant mill was built in 1854, at Minneapolis, Minn. New process flour manufacture necessitated the use of much expensive machinery, the result of which was that many small and scattered mills found it difficult and frequently impossible to maintain more than a local trade.

The Grain.—A detailed description of the numerous operations and processes to which cereals are subjected in the modern flour mill is beyond the scope of this review. The mechanical appliances represent a high order of inventive and mechanical ability. The objective point of all appliances is to deal with the individual grain. To do this involves more than blind mechanical knowledge. The grain is a perfect little organization and demands to be treated according to its nature. It has its covering, which needs to be properly removed. The interior food substance is not all exactly alike and in securing it great mechanical care has to be exercised.

Two grades of wheat are known to the millers—winter wheat, sown in the fall, which comes up in the spring, and spring wheat, which is harvested in the fall. Winter wheat is softer and more starchy; spring wheat harder and richer in gluten. There are three grades of process flour—namely, high grade, baker's flour and low grade. Graham flour contains all of the wheat and the husk. Whole wheat flour includes only part of the husk. Gluten flours exclude much of the starch and is designed for use by persons of impoverished digestion. Self-raising flour is flour mixed with some chemical-leavening agent, and its constituents usually are water, 13.30; proteids, 10.10; moist gluten, .27; dry gluten, 9.65; ether extract, .70; ash, .4; carbohydrate, 72.90.

Cereal Cultivation, the Basis.—The industry is the basis of the country's prosperity, and it owes much to the American railway system in providing means for transportation to markets. Upon the foundation of agriculture an enormous superstructure has been reared, and exhaustive and intelligent methods have been applied. Mechanical methods have been introduced wherever possible to lessen labor or to secure the greatest possible return from a given effort. In no country in the world is there such a vast extent of land fit for cereal cultivation. The requirements of this vast and expanding agricultural community are, as to mechanical appliances, supplied by the implement and tool-making industry, whose volume of products runs into many millions of dollars. Agriculture is the chief source of freight traffic for upward of fifty thousand miles of railroads and affords the chief source of employment for a large number of lesser industries which afford remunerative employment to many artisans and workmen. America is the granary of the world, and its cereal products are being increasingly called for in all parts of the world. The possibility of obtaining good food is encouraging an Asiatic demand, even to the material modification of the diet of a considerable number of people of Asia.

The American Farmer.—America, through her farmers, is conducting a crusade for a higher civilization and which, unlike the crusades of the dark ages, which had for their aim and end only a sentiment, is lifting the people out of old ruts and is attracting them to higher standards and to greater activities through industry.

Summary of the Flouring and Grist Mill Industry.

	1880	1890	1900
Number of establishments	24,338	18,470	25,258
Capital invested	$177,361,878	$208,473,500	$218,714,104
Wage-earners	58,407	47,403	37,073
Wages paid	$17,422,316	$18,138,402	$17,703,418
Value of products	$505,185,712	$513,971,474	$560,719,068

Food Preparation.

Growth of the Industry. — The production of food preparations, of which for a large part cereals form a base, has, during the past fifteen years, reached phenomenal proportions. Many of the plants engaged in this industry are located in Ohio and Michigan because of the advantages secured in obtaining raw material by rail and water and because of the abundant facilities for quick and economic distribution of products, but the industry has spread over a large area of the United States. These preparations are variously known and are regarded as pure forms of food.

Processes.—The processes by which these various foods are converted into condition for domestic use are substantially similar, but modified, however, in numerous details according to the nature of the product. The object of these processes is to utilize all the nutritious elements and preserve them until final use.

Other Preparations.—There are numerous valuable food preparations beside cereal preparations made from the products of the vineyard, orchard and garden which naturally come under this general heading, the preparation of which involves numerous special mechanical processes of comparatively recent invention. Almost all garden and orchard products are now converted into food preparations which are wholesome, nutritious and attractive in their marketable shape. The science of food preparation is endeavoring to solve the problem of concentration of food essences into solid shape, as in various forms of tablets, and while some interesting results have been reached the commercial results have not assumed the anticipated proportions of the enthusiastic advocates of this advanced and somewhat problematical purpose of the manufacturers.

Economy in Housework.—Household labor and kitchen administration are wonderfully simplified by these preparations, which are sold at a price below those which individual household preparation could meet. Hundreds of toothsome and nutritious articles of food are rendered available for ready use in the food-manufacturing industry and an immense and steadily growing industry is the outcome.

Extraordinary Growth of Output.—The wholesale preparation of foods for general domestic consumption might almost be regarded as a discovery. In 1880 the value of these products was $2,493,224. In twenty years the value of the output had increased almost sixteenfold. Householders, hotel keepers and others, as soon as they discovered that they could buy prepared foods, quickly relinquished the labor of their preparation.

Influence of Machinery.—The extraordinary demand which set in for all manner of food preparation soon attracted the attention of machinists and inventors, and there soon appeared a number of processes and mechanical appliances which transformed and revolutionized methods previously prevailing. The industry rapidly extended throughout the country and hundreds of plants soon arose equipped with machinery of great capacity where vast quantities of products were swiftly converted into edibles.

Chemistry in Food Preparation. — One of the modern developments in food preparation is the increasing knowledge of the constituents of food with relation to nourishment. Chemistry has done much in facilitating and forwarding this investigation and is adding its influence to make absolutely necessary a knowledge of the properties of all foods and their best preparation.

National Legislation.—National legislation has also taken hold of the question and laws have been enacted which forbid and punish food adulteration. Adulteration has reached alarming proportions and the unchecked manufacture of foods with various adulterants has reached proportions which demand the exertion of the power of the Federal Government to suppress it.

Adulteration.—The greater part of the adulteration practiced cannot be detected by eye or taste or touch, and hence the rapidity of its growth under the spur of competition and the desire of the masses to obtain necessities at the lowest cost.

The evils perpetrated are abundantly testified to by experts, physicians and others. The increasing dependence of the masses of the people on prepared foods renders it of the greatest importance that every possible measure of protection be taken to secure to them pure foods and honestly-made goods.

Comparative Summary of the Food Preparation Industry.

	1880	1890	1900
Number of establishments...	109	302	644
Capital invested.	$1,293,905	$6,715,535	$20,998,102
Wage-earners..............	1,333	3,478	8,154
Wages paid................	$318,253	$1,222,913	$3,051,718
Value of products..........	$2,493,224	$14,105,485	$38,457,651

Foundries and Foundrymen.

Foundry and Forge.—The foundry and forge of the early days were closely related. Prior to the introduction of the stove, the early foundrymen found employment in the production of minor utensils and appliances, which very faintly indicated the future of that great craft whose mythical founder was Tubal Cain. When at last the stove, as we know it to-day, appeared, the foundryman saw his opportunity. The first stove-plates were cast at blast furnaces.

The First Stove.—What was probably the first stove made in the United States was a "jamb stove," manufactured by Christopher Sauer, of Germantown, Philadelphia, somewhere between 1730 and 1740. In 1742 Benjamin Franklin invented a stove, which became the standard of that day. The pieces were cast at the Warwick Furnace, in Eastern Pennsylvania. This stove revealed foundry possibilities, and foundries and blast furnaces began to spring up in the train of the early forges, which began to turn out minor equipment for the early machine shops. Troy, N. Y., early began to be the center of the stove trade, because of the discovery of near-by molding sand. Albany soon after became a stove and foundry center.

Early Products. — The cannon-balls used by General Jackson at the battle of New Orleans were cast in a foundry in Western Pennsylvania in 1797, and were transported down the Ohio and Mississippi rivers. Large quantities of hollow-ware, "Dutch" ovens, stoves, sugar kettles, pots, grates, irons and plow castings, latterly termed "points," were produced in the ever-increasing foundries in ever-increasing quantities. These products found their way, by rivers and lakes very largely, into the newly opened-up sections South and West and Northwest.

Early Foundries. — Furnaces were early established in New Jersey at Oxford, Phillipsburg, Hackettstown, Port Oram and Stanhope, because of the local supplies of iron ore. These furnaces attracted rolling mills and steel works to Trenton, Dover, Newark, Boonton, Phillipsburg, Paterson and Passaic. Pennsylvania offered peculiar opportunities to the early founders by reason of its abundant and cheap coal and charcoal and iron, and they thrived decade by decade. Pittsburg early became an important center because of its water communication with the West, and its Conestoga wagon trains eastward over the mountains, and later the State canal, which afforded easy and cheap transportation to the springing-up villages which that waterway encouraged.

Statistics.—A reference to only the last decade is sufficient to indicate the remarkable progress of this industry. In 1890 there were 886 foundry establishments in Pennsylvania, employing 38,247 wage-earners, who produced values estimated at $67,587,025. In 1900 there were 1,260 establishments, employing 62,828 wage-earners, whose products were worth $127,292,440. In New York the increase in that decade was from 1,081 establishments to 1,352, from 39,133 workers to 50,173, and value of products showed an increase of 34.1 per cent. Taking Ohio as another representative State, it appears that the number of foundries increased from 600 in 1890 to 861 in 1900, number of employés from 24,975 to 41,799, and the value of products from $3,617,072 to $72,399,632, an increase of 66 per cent. in value of products. The statistics of these three States will suffice to indicate the general trend of the industry.

Some Early History. — The foundry industry may properly be regarded as the first industry in America. Way back in 1646 the Colony Court of Massachusetts granted a monopoly for fourteen years to Joseph Jenks for the making of engines for mills "to go by water," and for the making of "scythes and other edged tools." He was the first founder who worked in brass and iron on the Western Continent. Wire drawing and the manufacture of wool cards soon followed. Out of the foundry of Hugh Orr, in 1748, came the first musket ever made in America, and his son made shovels. The early founders learned how to make nails, and it was in the Plymouth Colony that they were first produced. Jacob Perkins, of Newburyport, invented a nail machine in 1795. Founders at Worcester, Mass., learned how to turn out hardware, tools and machinery. The production of artisans' tools, which laid the foundation of New England's industries, soon began. The founder had to be a tool-maker and machinist, and supply whatever inventive talent and skill that was necessary.

The Blast Furnace.—A turning point in the founders' craft was the production of iron by the modern blast furnace, and particularly the production of a grade of iron known to the trade as No. 2 foundry, with varieties of texture, an iron possessing special features for casting into any desirable shape by use of molds. Foundries became the necessary accompaniment of the machine shop, and constituted the basis of one of the greatest industries to which the skill of man has addressed itself. They soon spread over New England and the Middle States, and with the expansion of Western railroad building they sprang up in cities, towns and villages, contributing their coöperation to the upbuilding of the vast and complex industrial superstructure.

Relation of Steel to Foundry Work. — An epochal event was the production of steel at low cost and in large quantities, suitable for tools, machinery, agricultural equipments and shop and factory appliances. This resulted in an expansion of the founders' craft beyond its original and customary limits. The production of crucible and open-hearth steel almost wrested the control of the early founder from him, by reason of the introduction of different methods of manufacture and for a vastly increased number of utilities which were beyond the scope of the early founders.

Pipe Making. — The casting of pipe, properly speaking, is an allied industry, but entitled to consideration with it. The cast-pipe industry, a branch of foundry work, has reached extraordinary proportions because of the need of pipe to convey water, especially, for municipal requirements. The growth of cities and the springing up of towns, each needing abundant supplies of water, have created requirements which sustain, in almost uninterrupted activity, one of the most important branches of the great foundry industry.

New Substitutes.—The founders' craft is being invaded by modern improvements, among which are house-heating appliances, furnaces, heating by gas, oil, etc., in which centralized sources of heat predominate over isolated sources. But the field of the foundryman, for all that, is enlarging in other directions, notably in the direction of requirements of communities outside of dense centers of population, where individual necessities still call for attention.

Receipt for Crucible Making. — A receipt for making fire-clay crucibles is, 2 parts Stourbridge clay, 1 part hard gas coke finely powdered. To make Berlin crucibles, take 8 parts Stourbridge clay, 3 old crucibles ground finely, 5 parts coke, 4 of graphite or blacklead.

To make blacklead crucibles, take 1 part fire-clay and 2 parts graphite.

Another way is to mix 3 parts graphite, 1½ parts fire-clay, with water into a paste; press in molds and dry, but do not bake hard in a kiln. This compound makes good small furnaces.

Useful Foundry Rules.—The average weight of a cubic inch of cast iron is .26 or 26-100 of one pound, or 1-100th part more than ¼ pound. Thus, if your product is in cubic inches, multiply by .26, and your answer will be the weight in pounds. Consequently the weight of a square foot 1 inch thick will be 37.44 or 37.5—that is, 37½ pounds, as there are 144 square inches in a square foot. But for convenience and allowing for fillets and strains, it is much easier to call a square foot 40 pounds. A cubic foot weighs 450 pounds. If these items are committed to memory it will be very easy, when you get the area or solidity, to get the exact weight.

To find the area of a surface the rule is to multiply the length by the breadth. Example: If a plate measures 6 × 8 feet, you would say 6 times 8 = 48, which is the area. If the plate were but 1 inch thick, then its weight would be 48 × 40, or 1,920 pounds. If a square foot of iron 1 inch thick weighs 40 pounds, it would only weigh 5 pounds if it were ⅛ of an inch thick — that is, 40 ÷ 8 = 5 pounds. Thus we have the rule, for every ⅛ of an inch in excess of an inch in the thickness of a plate add 5 to the 40 for a multiplier, and conversely, for every ⅛ less than an inch subtract 5. Thus, if the plate above mentioned were 1¼ inches thick, you would multiply by 50; if 1½ inches, by 60; if 1¾ inches, by 70; or 2 inches, by 80; if it were ⅞ of an inch thick you would multiply by 35, and so on.

To find the area of a round plate you would proceed a little differently, for to find the area of a circle you square the diameter and multiply the product by .7854. Thus, if it were 3 feet in diameter it would be 3 × 3 × .7854 = 7.0688 feet, or a very small fraction over 7 square feet. Then the weight would be 7 × 40 = 280 pounds, if it were 1 inch thick.

In measuring a cylindrical body, like a pipe, for example, take the diameter to the center of the thickness, or from the outside on the one side to the inside on the opposite side, which is the same thing, but much easier, and multiply by 3.1416, or by 3, adding thereafter 1 foot for every 22 in the product. This will give you the width of a flat plate equal in width to the circumference of your pipe. Multiply by the length of the pipe, and you have its area, and can proceed as already described to determine its weight. For example: If we had a plain cylinder whose outside diameter was 12 feet and inside diameter 10 feet, from the outside diameter on the one side to the inside of the other would be 11 feet. Then $11 \times 3.1416 = 34.5576$ feet, or 34 feet $6\frac{3}{4}$ inches; or, adopting the other method, $11 \times 3 = 33$ plus 1 foot for every $22 = 33 + 1\frac{1}{2}$, or $34\frac{1}{2}$ feet. Now, if the height of the cylinder were 10 feet, you would say $34\frac{1}{2} \times 10 = 345$ feet, area of plate which forms the cylinder. Again proceeding as in the case of a flat plate, you can readily determine the weight.

Rule to find the weight of a round ball: Cube the half of the diameter in inches, and divide the product by 10 as a constant and add. Example: If the diameter of a ball is 8 inches, the half is 4; so $4 \times 4 = 16$, $16 \times 4 = 64$; divide by constant number 10, $64 \div 10 = 6.4$. Thus, $64 + 6.4 = 70.4$ pounds cast iron.

Rule No. 2: Nine times the cube of the diameter being divided by 64 will express the weight in pounds. Example: Find the weight of a ball whose diameter is 5 inches. $5 \times 5 \times 5 = 125 =$ cube of ball's diameter. Then $125 \times 9 \div 64 =$ 17 37-64 pounds, the answer.

To find how much iron a ladle will hold, find the diameter at the top, center and the bottom, add the three diameters and divide by 3, which will give you the average diameter; or simply take the diameter of the center. Square the diameter and multiply by .7854, and the product by the depth, which will give you the cubic capacity. If the result is in inches, multiply by .26, or if the result is in cubic feet, multiply by 450, and the result will be the weight in pounds.

To find the strength of chains, square the diameter in eighths, and divide by 8. Example: Three-quarter-inch chain is 6-8, then $6 \times 6 = 36$; $36 \div 8 = 4.5$ tons. In some cases they use 6 as a divisor, which would make the chain a 6-ton chain. The United States Government allows 10,000 pounds to the square inch. The ton referred to here is the standard ton (2,240 pounds).

To find the safe working load for common ropes, square the circumference in inches, and multiply by 4; the answer will be in hundredweights.

For chains and ropes that are in everyday use these divisors are safe; in chains, use the divisor 8.

Weights of Useful Metals.

NAME OF METAL.	Cubic foot—lbs.	One ft. sq. by 1 in. thick—lbs.	Bar 1 in sq. by 1 ft. long—lbs.	Bar 1 in. diameter, 1 ft. long—lbs.
Cast iron	450	37.5	3.12	2.45
Wrought iron	475	40.5	3.33	2.61
Steel	490	40.8	3.40	2.67
Copper (cast)	549	45.7	3.81	2.99
Gun metal	510	42.5	3.54	2.78
Brass (yellow)	523	43.6	3.63	2.85
Lead (cast)	710	59.3	4.94	3.88
Zinc (cast)	439	36.6	3.05	2 40

As common white pine is sixteen times lighter than cast iron, you can weigh the pattern, providing the pattern is solid, and multiply the product by 16.

Comparative Summary of Foundry and Machine Shop Products.

	1880	1890	1900
Number of establishments	4,984	6,500	9,324
Capital invested	$155,021,734	$383,257,473	$665,058,245
Wage-workers	145,650	231,331	350,327
Wages paid	$66,093,920	$129,282,263	$182,232,009
Value of products	$215,442,011	$413,197,116	$644,990,999

This summary includes, as is observed, machine shop products, the Government not having separated machine shop products from foundry products proper.

Fountain Pen Manufacture.

Twenty Processes to Make a Pen.—In the manufacture of a fountain pen there are about twenty different processes between the raw material and the finished product. The turning of the hard-rubber handles is almost exclusively lathe work, and requires expensive tools. These tools dull very rapidly in turning hard rubber, and must be frequently sharpened or replaced. The cores are turned to an exact size, made to fit precisely in every part, and are highly polished. The most complete plants make their own gold pens, starting with gold in the bar. The gold, after being melted and alloyed, is cast into a brick or block, then rolled out into a long, thin ribbon, and from this, under high-pressure dies, the pens are cut in various sizes. After this they are trimmed, pointed, split, shaped, polished and marked. When the pens are heated to a malleable point, a tiny fragment of iridium, so small that the workmen must use a magnifying glass to see it, is welded on the point. When the pen is later split, this fragment of iridium, small as it is, must be sawed exactly in half. This delicate operation is accomplished by a small disk of copper, revolving like a circular saw at high speed. After this each section of the iridium tip is ground, under magnifying glasses, into eight equal faces on the exposed side that will touch the paper. This requires extremely careful workmanship, and of course adds to the cost of the pens of the better class.

Ornamenting Pens.—Many pens are ornamented with chasing, and in the more elaborate holders gold and silver bands or embossing are added. The security of the pens, however, is found in perfect adjustment of the parts, that prevents leaking and which regulates exactly the proper flow of ink. Only accurate workmanship on the rubber tubes can secure this.

Centers of Production.—The fountain-pen trade has doubled during the past five years. From the first of September until after the holiday trade the pen-makers have their busiest season. Some plants produce as many as 30,000 pens per week. The manufacture of rubber cores is a separate industry, in which machinery of extreme fineness and exactness is used. New York leads in the production; Ohio comes second.

Two Systems of Pen Making.—In the original design of fountain pens there were two types, known as the Schaeffer and the Parker hydraulic pen. The Schaeffer had a reservoir for ink in the holder, and the ink was admitted to the pen by the pressure of the thumb on a projecting stud. The Parker pen also had a reservoir in the holder, which contained a piston operated by a screw stem and a nut in the end of the holder. The lower end of the reservoir being dipped in ink, the piston was drawn up by rotating the nut, thus filling the reservoir. The ink was rejected as required by a reverse motion of the thumb nut.

Early Construction.—The early fountain pens had appliances such as tubes, ducts, valves or springs operated upon by the action of the nibs, which forced the ink from a feeding pipe upon the pen, assisted by air admitted to the top of the holder to take the place of the exhausted ink. After many experiments to secure a continuous and properly regulated flow, it was found that the best results were obtained by the use of a tubular holder, tightly closed at its upper end and at the lower end fitted with an ordinary nibbed pen made of gold, with an ink-feeder lying adjacent to the pen to attract the ink from the reservoir. As the ink in the process of writing is withdrawn, the air enters at the lower end of the holder and ascends in globules through the column of ink to fill the space left vacant. During the past ten years 185 patents have been granted, and during the same time 29 patents were granted for "fountain pen attachments," "fountain pen holders," "fountain marking pens," etc., and several patents for "reservoir pens."

Statistics. — In 1900 there were 23 establishments making fountain pens, employing 318 wage-workers, to whom was paid in wages $141,000, producing pens with a factory value of $906,454.

Fuel, Artificial.

Use of Waste Material.—Remarkable improvements have been made, especially during the past decade, in the manufacture of artificial fuel. Quite a number of methods have been devised to manufacture fuel to suit certain requirements and to utilize waste material, particularly the culm and slack of coal mines. A large number of machines have been made for briquetting fuel, and all of these machines possess features which commend them, but the abundance of natural fuel obstructs their use.

Varieties.—There is a great variety of artificial fuels, but none have to a very serious extent supplanted the customary fuels on the market. The cheapness and abundance of coal, and the increasing abundance and cheapness of oil for fuel purposes, are obstructing the growth of specially made artificial fuels. In addition to this, all steam-generating appliances are either built for coal or are readily adaptable to the use of oil as fuel. At the same time, there is a growing requirement for artificial fuels, and the minor industries which are engaged in their production are meeting with a fair degree of encouragement.

Furniture Making.

Groundwork of the Industry. — The furniture industry in the United States has assumed extraordinary proportions during the past twenty-five years by reason of the convergence of several actuating causes, among which may be mentioned the perfection of the mechanical appliances for working in wood, the production of large quantities of parts by the same machine, the reduction in cost, the improvement in quality and appearance of work and the growing necessities of the people for domestic conveniences into which furniture so largely enters. As a separate and distinctive industry it has not had a very long existence. The old-time cabinet makers and chair makers, as well as the carpenters, endeavored to piece out the requirements of householders as best they could with their kits of tools and meagre shop facilities.

Rise of the Industry.—When the flood of mechanical appliances appeared, with the steam engine and cheap and abundant fuel, a new industry was born, which soon assumed extraordinary proportions. Some of the credit of this is due to the planing mill manufacturers who made the work of the furniture manufacturers comparatively easy. The machinist deserves a still larger share for the assistance he rendered in opening the way for this industry, by inventing and building a number of wonderful wood-working appliances that did almost everything which human hands could do. The furniture industry, as an industry, is distinctly of American origin, although vast quantities of furniture has been made for the past two centuries in English, French and German shops and some of their workmanship comes down to this day unequaled in beauty, excellence, endurance and finish.

Distinctive Features.—The distinctive American feature in furniture is that it is largely the product of mechanism operated by steam. The excellence of the work, when excellence was sought after, coupled with the comparatively low price of the cheaper grades of work, laid a broad foundation for the industry. The abundance of wood, its great variety, its fine texture, its capacity to take fine finish, all helped to expand the industry to its present proportions.

Conditions and Influences.—Another direct influence is the fact that most American houses have a great similarity in construction and shape. Furniture that suited one house is likely to suit another. Then the tastes of the masses of the people are very much in accord. Manufacturers felt secure of markets. The building of railroads, which has connected every city and town and every considerable village, opened a market for furniture products. The system of public school education has helped to maintain a demand which calls for desks, tables, chairs and some other products. Household requirements are to a very large degree similar, and hence it is that furniture manufacturers feel safe in establishing large furniture manufacturing plants.

American Styles.—The American public have escaped that tendency to monstrosity in furniture which has manifested itself in some other countries. It has also escaped very largely the fever of imitation of Oriental or mediæval furniture, which bears no proper relationship to the tastes and wants of our people. Genuine taste now very generally prevails in the selection of furniture in most homes, and gaudiness and extravagance or inharmonies in design are generally avoided.

Material Used.—While much furniture is produced at remarkably low cost, it is well made and endurable. The lumber employed is properly seasoned and when it enters the finishing department it is subjected to skillful hands who impart a degree of finish which in the earlier history of the industry was reserved for the higher grades. The use of mahogany has increased because of the increased cost of cheaper woods. Cuba, Yucatan and Mexico are now freely called upon for supplies, as well as other countries. Walnut was for a long time much prized because of its fine grain and susceptibility to polish. Quartered oak became very widely used in the production of what was, for a while, known as antique furniture, but it is now used for a great variety of ordinary uses.

Imitation Furniture.—A stimulus was imparted for a while by imitation. Expert manufacturers devised methods for making cheap woods appear as rare woods. This was made possible by the great advance in the art of varnishing and staining. Cabinet makers now find they have to depend less on fine woods, but the wealthier patrons of the furniture manufacturers' art discourage imitation of the real wood. The transformation effected in cheap lumber, such as pine, chestnut, poplar, etc., in the furniture factory, is surprising to those unfamiliar with the extent to which the art of imitation has been developed.

Recent Trade Tendencies.—The trade has to a considerable extent centered in certain localities, where immense establishments have been built up, wherein every mechanical device is found to increase and cheapen output, but no locality possesses exclusive advantages. Nearness to suitable lumber is the essential point, and next to this, facilities for reaching the great distributing centers. One of the features developed in furniture making is the folding or "combination" feature, by which the article can be placed in more compact space when not in use. Many articles are thus imitated, including beds, bookcases and writing desks. The industry is being developed by the steady improvement in machinery and in quality, while the cost of attractive and serviceable furniture is being brought within the reach of an increasing number of buyers.

Colonial Furniture.—The colonial furniture so much prized to-day belongs to what is known as the late colonial period, in contradistinction to the early colonial, which was a composite assortment of quaint furniture, usually of Dutch origin, and Chinese and East Indian decoration.

Design of Furniture.—Beauty of design is essential in furniture making. The main point is to secure proper proportion in the dimensions of the different parts of a piece of furniture. Some furniture, if subjected to strains, falls to pieces; and frequently too much of the strength of construction is sacrificed to lightness and style. The drift of fashion is latterly toward old-fashioned massive construction.

Finish.—The first essential of good finish is a good surface. The time to begin is as soon as the stock leaves the stock cutter. Unless the stock is faced straight and true, the planer work will be poor; if the piece is crooked, warped or twisted when it is planed, it will remain so after it is planed.

Sander Work.—The quality of sanding determines the quality of the planing. If the material comes from the planer gouged, rough or crooked, it is next to impossible to get a perfectly sanded surface, for the gouges and marks of the planer will be copied by the sander, sometimes leaving a mark for every revolution of the cylinder. In high-priced goods the surfaces are generally hand-sanded, which is followed in some factories by a buffing or polishing machine.

Pressed Wood Pulp.—The invention of pressed wood pulp has materially reduced hand-carving, but there is a reaction to hand-work, due in a measure to the introduction of Chinese wood carving, particularly as shown in the remarkable teakwood sideboards and tiles of Chinese handicraft.

It is becoming the fashion once more to own a hand-carved set of furniture which will last for a lifetime, rather than several factory sets made to suit the different prevailing styles. The advantage of hand-carved furniture is appreciated by the wealthy, who wish no duplicate of their articles. A workman who can make enduring the chair, table, sideboard or bookcase by giving it an artistic effect of his own, is a benefactor to his trade. He has established a permanent influence in a home which will be felt by after generations.

Arts and Crafts Furniture.—All kinds of furniture are now offered under the name of Arts and Craft, from freakish exaggerations to those possessing dignity and lasting worth. Before selecting one should be able to distinguish the good from the bad. For instance, a bed with heavy square posts, like the supporting timbers of a bridge, beneath a canopy top frame solid enough for a house, suggests a mausoleum rather than a bed. While for a man's room of severe design the weathered-oak furniture and finish may be good, the heavy and clumsy in design is certainly out of keeping in a bedroom.

The Arts and Crafts pieces are most suitable for halls, libraries and dens, especially when combined with rich tones of Spanish leather. Its rich color is lasting and gives opportunities for contrast.

Dainty Guest Sets.—The guest-chamber writing desk sets now manufactured are exceedingly dainty. These are covered in linen taffeta, of light flowered design. Other styles of desks are of pale gray with a design of wreaths of pink roses tied with lovers' knots of blue ribbon.

Fine Linings. — Besides the writing-desk sets, glove and veil boxes, lined with satin to harmonize with the linen taffeta covering, and a shirt-waist box are added to this attractive guest chamber outfit. Then, if a seat is upholstered to match, and the overhangings at the windows and doors are of the same, the result is all a housewife's heart could desire.

Comparative Summary of the Furniture, Cabinet-Making and Upholstery Industry.

	1880	1890	1900
Number of establishments...	6,088	5,973	7,972
Capital invested............	$47,831,529	$93,642,147	$117,982,091
Wage-earners................	62,662	83,587	100,018
Wages paid..................	$25,048,414	$40,816,566	$42,638,810
Value of products...........	$85,004,618	$135,627,332	$153,168,309

Furs and Fur Manufacture.

Supremacy of the United States.—The United States leads all the countries of the world in the marketing of furs, shipments amounting to nearly one-half of the world's production. Three-fourths of our enormous supplies are derived from animals that live in the water. The most important fur-bearing animal is the muskrat, our contribution amounting to over 4,000,000 skins, largely utilized to produce imitations of more valuable furs.

American Supplies.—The supply of aquatic furs in 1902, which represents a fair average in comparison with the world's supply, was 80 per cent. of muskrat, 70 per cent. of mink, 35 per cent. of otter, 30 per cent. of fur seal and 12 per cent. of beaver. Canada averaged about one-half these percentages. The muskrat furnishes about one-half of all the skins marketed.

Furs Long Ago.—During the Middle Ages and up to as late as 1600, Russia was the chief source of the world's supply. The opening up of North America transferred the world's chief source to this side of the Atlantic, and New York City, under the commercial genius of John Jacob Astor, early became the center of collection and distribution, as well as dressing, dyeing and finishing of furs.

More Valuable Furs.—Among the more valuable animals for fur purposes may be mentioned the muskrat and the nutria or "coypri," a small beaver-like animal found chiefly in South America, where 2,000,000 are secured annually. The most valuable aquatic fur is that of the sea otter, but it is exceedingly scarce. Previous to 1890 the fur seal was in larger supply, but to-day mink predominates.

The Hunters and Trappers.—The world owes its supplies of furs to bands of indefatigable hunters and trappers, who spend their outwardly dreary lives in remote regions, where, with a sort of sportsmanlike enthusiasm, they secure fur-yielding animals through skillful efforts. The skins are far from attractive when first presented to the merchant, and only faintly suggest the wide difference between the original and the prospective users.

Muskrat and Mink.—The supply of muskrat skins in 1902, which shows a fair average, reached 4,000,000. During the last century it is estimated that the United States and Canada furnished 250,000,000 skins, which, if spread out, would cover nearly seven square miles. The fur is dense and soft, somewhat like the beaver, but shorter and less fine, and partly concealed by brown overhair on the back and sides. Climatic conditions in the Chesapeake and Delaware bays on the Atlantic coast impart a dark color to the fur, to which the name "black muskrat" is applied, and which is highly valuable, while in Alaska the fur is of a light silver color.

Methods of Manufacture.—The skins are first made soft and pliable; with the fur seal the overhair is removed to show the beautiful undercoat. The pelts are then soaked in water, scraped with a dull knife or piece of hard wood to break up the texture of the skin, and made pliable; if too thick, it is shaved thin.

The Tubbing Process.—The skins, after being placed in proper receptacles, are trodden by the bare feet of workmen or by machinery, next placed in a revolving drum with sawdust, to remove grease, then beaten to remove the sawdust, and combed with a steel comb.

Dyeing of Furs.—Fashion steps in with its imperious demands, and various shades are produced, one of which is the lustrous blackish brown in the sealskin, unknown to nature. Beaver and otter are silvered by a solution of sulphuric acid; a golden tint is produced by peroxide of hydrogen. Dyed furs are usually deteriorated by the process, but expert chemists are gradually overcoming this defect.

Mink Furs.—Few furs surpass the mink in richness of coloring, quality and durability. Thirty years ago mink enjoyed the stamp of fashion's approval, but declining supply forced the acceptance of other skins. Mink sells to-day at one-sixth the price of forty years ago. Efforts to rear the animals in captivity failed.

Old-Time Use of Aquatic Furs.—During the seventeenth and eighteenth centuries aquatic furs were largely used in Europe to manufacture "beaver" hats. Beaver fur is still utilized to make very soft and light hats, which wholesale at upward of $100 per dozen.

Comparative Statement Showing the Condition of the Industry in the United States.

Years.	No. of Establishments.	Wage-earners.	Wages Paid.	Value of Products.
1900	994	8,588	$4,273,192	$27,735,264
1890	484	6,947	3,477,148	20,526,988

Gas Engine, The. Illuminants and Apparatus.

Development. — During the summer of 1903 there was completed in the city of Cleveland, Ohio, two gas engines of 4,000 horse-power. When the Westinghouse Company announced its purpose, a few years ago, to construct a gas engine of 1,500 horse-power, it was regarded by many as impossible of execution. Large unit gas engines have been developed in the United States, where they are used for a variety of purposes, including the pumping of natural gas by the Standard Oil Company and other oil companies.

Uses of Gas Engines.—The function of the gas engine is to convert into power the impulse of an explosion of a mixture of fuel gas and air. With the poorer gases it is necessary to compress them first before satisfactory ignition and combustion can be effected. The action, therefore, of the gas engine is the drawing or forcing into the engine cylinder of a mixture of gas and air, and, after the completion of the stroke, the expulsion of the gases of combustion. As a result of the explosion there is a marked rise in the temperature, which might prove dangerous to the life of the engine. Elaborate cooling is therefore necessary, and the parts must be so designed that they will not suffer from temporary exposure to hot gases.

Kinds of Engines.—The most interesting of the European gas engines to American iron-makers, where blast-furnace gases are used, is the Koerting, in which the mixture of gas and air is supplied by two auxiliary pumps driven by a crank from the main shaft, and operated by one rod. The preference in Europe is given to the open double-acting cycle engine for from 300 to 400 horse-power. For larger machines the double-acting four-cylinder engine and two-cycle engines are preferred. For very large horse-powers, up to and over 1,000 horse-power, two-cycle engines are recommended.

Small Engines.—It is with the smaller gas engines, from one horse-power up to fifty and more, that the greatest interest is felt. These small and easily operated and absolutely safe engines exercise a remarkable influence in manufacturing. They are built in enormous numbers by many firms, and are adapted to a vast variety of uses. The cost of operation is low, and they can be utilized in a multitude of cases where steam-power is scarcely available.

Place of Gas Engines.—The building of gas engines has developed a special class of mechanics, who possess skill in building engines made to be run without skilled labor. While the fundamental principle in all engines is the same, there is a great variety of mechanical adaptations which confer on them special value for specific purposes. Their use is rapidly extending, and they are to-day performing no inconsiderable percentage of the shop-work of the country. Their cleanliness, availability, safety and economy are steadily broadening their field of use, and it is safe to say that the field of the gas engine may extend even faster than that of its big brother, the steam engine.

Engine Types.—The large increase in the use of internal-combustion engines during the past few years is due to a number of influences and conditions. These engines are capable of quite a multiplication of types. Remarkable improvements in construction have been made, and the efficiency has been increased to a wonderful degree. The application of the principle of the gas engine to units of great size is a mere matter of mechanical construction. The gas engine using ordinary illuminating gas, igniting either by a hot tube or an exposed flame, which constituted its features ten years ago, has been transformed in a more marked degree than in any other heat engine. Gas engines, as they are known, are now constructed for operation with illuminating, natural or producer gas, or with gasoline, kerosene or alcohol. The electric spark has largely taken the place of the hot tube or exposed flame for ignition of the explosive gaseous mixture in the cylinder.

Largest Engines.—In 1893 the largest gas engine exhibited at the World's Columbian Exhibition at Chicago was a 35 horse-power, while at Paris in 1900 a 1,000 horse-power engine was shown, actuated with ordinary illuminating gas. Since then, 1,500 horse-power engines have been erected, and the latest pending increase of capacity contemplates, it is said, the exertion of energy equal to 4,000 horse-power.

Small Shop Engines.—There has been an extraordinary stimulus imparted to the construction of engines of from 3 to 40 horse-power, which are wonderfully compact in construction and economical in operation. The operations of small shops are conducted satisfactorily by these engines, and small boats and yachts are propelled. A Holland submarine boat is propelled by a 190 horse-power engine, and in yachts steam power has been supplanted by gas power.

Fuel and Water. — With plants of 250 horse-power or more, under every-day working conditions, one brake horse-power per hour is produced from 1.25 to 1.50 pounds of bituminous coal, and the consumption of water does not exceed 2 pounds per brake horse-power per hour.

Power.—The steam from a good boiler plant represents about 70 per cent. of the heat developed by the combustion of coal. A good steam engine is able to deliver about 14 per cent. of the heat of the steam as power, giving a total efficiency of about 10 per cent. The gas from a power gas plant, on the other hand, contains over 80 per cent. of the heat of the coal. A gas engine delivers 25 per cent. of this power, making a total efficiency of 20 per cent. The most notable phase of gas-engine development is in the utilization of waste gases from blast furnaces for the operation of large engines or near-by rolling mills.

Statistics. — In 1900 there were in operation 18,531 gas or internal-combustion engines, with an aggregate horse-power of 164,662, representing a value of $5,579,398.

Acetylene Gas.—Acetylene gas is a combination of 2 parts carbon and 2 parts hydrogen. It was discovered in 1836 by Edmund Davy, and was followed in 1861 by the combination of carbon with calcium. Its production upon a commercial scale was due to the adoption of the electrical furnace in order to effect chemical reaction. The reaction is a very simple one. Lime and carbon mixed are subjected to the heat of an electrical arc, the carbon combines with the calcium of the lime and forms calcium carbide. Over 500 patents have already been granted for acetylene gas apparatus.

Commercially Produced.—Acetylene is now produced commercially by the mutual decomposition of water and calcium carbide, the latter giving off, when brought into contact with water, acetylene gas, which rises in bubbles. In the reaction the carbon of the carbide unites with a portion of the hydrogen of the water, producing acetylene gas, known chemically as C_2H_2, while the calcium of the carbide unites with the oxygen of the water and the remaining portion of the hydrogen, and forms calcium hydrate, or slacked lime.

Wilson Process.—In the Wilson process, invented in 1893-95, a mixture of lime and carbon is subjected to the heat of an electric arc, and the carbon combines with the calcium of the lime to form calcium carbide. This very simple and economic method has greatly stimulated its manufacture. This useful product is now largely manufactured at Spray, N. C.; Niagara Falls, Sault Ste. Marie and one or two other localities.

Variety of Methods.—In the different apparatus there is a variety of methods applied to bring the water and carbide into contact. Some of the devices discharge a regulated quantity of powdered calcium carbide into the water, while in others the water is discharged upon the calcium carbide.

Carburetted Air. — Carburetted air is another form of illuminating gas, which consists simply of air forced through some light hydrocarbon, such as naphtha, benzine or gasoline, and saturated with the vapors of these volatile substances, becomes an inflammable mixture.

Pintsch Gas.—Pintsch gas is made from oil, and is compressed in storage cylinders by means of pumps for portable use, under a pressure, sometimes, as high as 150 pounds to the inch. At the burners this pressure is reduced by pressure regulators.

Welsbach Burner.—The Welsbach burner has taken a high place among illuminants. It utilizes the Bunsen burner principle, and makes a very perfect combustion of the gas with the greatest possible heat and least smoke. This burner was brought out in 1885, and is a development of the Drummond light, invented in 1826.

In the Welsbach burner the light seen does not proceed directly from the combustion of the gas, but from the white-hot mantle. This light is a pure white one, and does not distort or falsify colors. The coating of the mantles with paraffine or similar material toughens them and prevents breaking in transportation and packing.

Statistics of Illuminating Gas.—The number of establishments manufacturing illuminating and heating gas increased from 742 in 1890 to 877 in 1900, invested capital from $258,771,795 to $567,000,506, number of wage-workers from 12,996 to 22,459, wages paid from $8,499,625 to $12,546,296, and value of gas from $56,987,290 to $72,716,693.

Gas and Oil Stoves.—The number of establishments making gas and oil stoves increased in the same decade from 24 to 35, capital invested from $1,199,528 to $3,766,065, wage-workers from 923 to 2,471, wages paid from $506,726 to $1,138,442, and value of stoves from $2,137,944 to $4,579,700.

Gas and Lamp Fixtures.— The number of establishments engaged in the manufacture of gas and lamp fixtures increased as follows:

	1880	1890	1900
Number of establishments	35	108	223
Capital invested	$3,248,400	$7,218,964	$10,009,239
Wage-workers	3,069	5,014	7,642
Wages produced	$1 469,287	$2,879,813	$3,504,301
Value of products	$4,329,656	$7,825,672	$12,577,806

Comparative Summary of Gas Machines and Meters.

	1880	1890	1900
Number of establishments	34	38	114
Capital invested	$1,147,000	$1,603,426	$4,605,624
Wage-earners	853	998	2,167
Wages paid	$397,108	$625,902	$1,185,959
Value of production	$1,334,991	$1,838,644	$4,392,730

Gas Machine and Meter Industry.

Statistics.—The very general use of gas has increased the number of establishments engaged in the manufacture of meters and gas machines from 34 in 1880 to 114 in 1900, in which were employed in those years 853 and 2,167 wage-workers respectively. The capital invested increased from $1,147,000 to $4,605,624 between those dates, and the value of products expanded from $1,334,991 to $4,392,730 in 1900.

Gas-Meter Device.—The gas meter is a simple device, operated by gas pressure, admitting a given quantity of gas, the consumption of which permits refilling. The pressure of gas is controlled both at the central office and at the point of consumption. The meter is a most convenient device for determining the amount of consumption and as a mechanical bookkeeper is presumably without error, though householders frequently attack its reliability and truthfulness.

Ingenuity. — Gas machines are increasing in number and capacity, and represent, in their more recent forms of construction, a high degree of mechanical ingenuity which makes them adaptable to an increasing number of valuable industrial, household and manufactory uses.

The Slot System.—One of the latest developments in the gas world has been the introduction of "prepayment" or "coin-in-the-slot" gas meters. They have met with great favor in England, and many thousands are in use in the United States.

These meters open many avenues for the sale of gas, and secure much additional business for gas companies. The advantages are many and well known. Complaining consumers are satisfied when the gas is paid for in small sums at a time, and when they are not required to go to the gas office every month to settle bills; consequently, more gas is consumed. There are many houses along the lines of mains in every city, where gas is not used or where services are idle. The occupants will not or cannot make a deposit, and without which it is not safe to supply gas. This business may be secured with the prepayment meter.

The inlet and outlet openings are located as on ordinary meters, and regular meter repairs can be made when required without affecting the prepayment attachment. The money-box, made of cast iron, cannot be picked, and it is, as well as all other parts, strong and durable. A special dial shows the amount of unconsumed gas paid for, and before the supply is cut off the lights are lowered as a warning. The meters, which are made in 3, 5, 10 and 20-light sizes, are furnished for 25-cent pieces and set for any price of gas. Adjustments can be easily made to suit altered rates.

Consumption of Gas.—The consumption of gas for illuminating and heating purposes increased, as measured by value, during the past decade from $56,987,290 in 1890 to $72,716,693 in 1900, all of which was measured by meters with exactness. Considering that the raw material cost only $20,605,356, the margins afforded were quite liberal. But the capitalization of gas companies is high, being placed at $567,000,506, on which, as a rule, good dividends are paid. The officials of gas companies are well paid for their services, the total amount for 1900 being $5,273,500, which is considerably in excess of the usual rate of compensation to officers of industrial companies.

Gas Manufacturing.

History.—The gas industry dates from 1806, when David Melville, of Newport, R. I., lighted his premises by means of coal gas which he manufactured. This took place nine years after the first gas-making experiments in England. In 1813 gas was made for a cotton mill at Watertown, Mass., and was used in Providence, R. I., in 1817. In 1816 a company was chartered to manufacture gas in Baltimore, Md., and in 1822 another plant was established in Boston, Mass. New York City adopted gas lighting in 1823; New Orleans, in 1835. As an illuminant, gas has a number of competitors, among them kerosene and improved oil lamps.

The Lowe Process.—The introduction of water gas by Lowe introduced a new era in the industry. Water gas is manufactured by a process in which hydrogen and the oxides of carbon, produced by the action of steam upon carbon at a higher temperature, are mixed and then combined with richly carburetted gases, usually from petroleum, thus producing the power of illumination. The first plant using the Lowe process was erected at Phœnixville, Pa., in 1873. Subsequently the water-gas process was very largely adopted in cities and towns throughout the United States.

Influence on Gas-Engine Industry.—A new opponent to gas appeared later on in the form of electricity, which resulted in the introduction of stoves for cooking and heating purposes. The economic manufacture of gas built up the gas-engine industry and added a very important department to the production of the engine industry.

Welsbach's Method.—By far the most potent factor in enabling gas to compete with electric light was the invention of Welsbach, which, with the incandescent mantle, is now in general use.

Oil, crude and refined, is the largest single item of material used in the manufacture of gas.

Comparative Summary of the Gas Industry.

	1890	1900
Number of establishments	742	877
Capital invested	$258,771,795	$567,000,506
Wage-earners	12,996	22,459
Wages paid	$8,492.797	$12,436,296
Value of products	$56,987,290	$72,716,693

Gas Stoves and Lamps.

Utility and Economy.—Quite an important industry has developed during the past two decades in the manufacture of gas stoves, as well as of lamps in which gas is used, in which artistic features are made to blend with the recognized utilitarian features. The making of stoves and lamps for gas is confined mainly to the large cities, where congested conditions render gas stoves especially, an important adjunct to the home. The processes of gas stove manufacture are simple, and the production has grown to large proportions because of their portability, convenience and economy. The gas stove, in stimulating the demand for gas, has aided in no small degree in extending the capacity of gas plants, no inconsiderable percentage of the supply being used in these stoves. They dispense with the cumbrous appliances for the generation of heat through coal and eliminate many of the undesirable features incident to that system of supplying heat. They also contribute indirectly to that tendency in these times of multiplying separate domiciles under one roof and enable families to conduct minor housekeeping with moderate satisfaction and much convenience.

The Gas Lamp.—The gas lamp industry of late years has taken on large proportions because of the evident advantages of cleanliness, freedom from odors and an always ready light which can be used whenever desired, without the dangers incident to the handling of oil. A total of 13,458 patents have been granted for oil and gas burners and their accessories.

Railroad Lamps.—One of the larger sources of demand for lamps is the railroad system, where practical utility is the supreme consideration. Railroad signal lamps are made to conform to numerous exigencies in which has to be considered ventilation, size of the focusing lens, the burner, material used in construction, accessibility of parts and their interchangeability. The proper focusing is the most difficult part of the work. To get the best results with a given flame, the brightest part of the flame must come within the focus of the lens. To obtain the most economical results, the brightness of the flame in the focus must be increased, and that part outside of the focus reduced as much as possible. Recent photometric tests of the light from various burners, when placed behind a 5⅜-inch lens, were as follows, the flat side of the flame being presented to the lens:

Tests. — Callender burner, 1.8 candle-power flame, 23 candle-power light; A. & W. or Dressel burner, 2.2 candle-power flame, 48 candle-power light; Zenith burner, 5.1 candle-power flame, 88 candle-power light.

Efficiency.—The small, round flame of the long-time burner, giving a light of ½ candle-power and consuming one-fifth the oil of the flat-flame burners, gives a light equal to 63 candles when put behind the lens. An electric light of 1 candle-power, but with small filament, all of which is in the focus of the lens, will give a light equal to 100 candles. A 16 candle-power electric lamp, with but a small part of the filament in the focus of the lens, will give a light of only 40 candles.

Arrangement of Flame.—If the flame be placed edgewise to the lens, a part ⅛ inch in diameter by ¾ inch long will be within the focus, and more light rays will be bent in the proper direction by the lens, the light from one part passing through the other part of the flame with but little loss. In proof of this, tests show that the increased efficiency obtained by turning the flame edgewise to the lens is about 50 per cent., the Dressel burner then giving a light equal to 103 candles, and the Zenith burner 179 candles.

But two style burners need to be used with the lamps—the flat burner and the long-time burner. But two oil-pots will be required, the long-time burner being shorter than the flat burner, and having to be raised to bring the flame in the focus of the lens.

Statistics.—In 1890 there were 24 manufactories of gas stoves and lamps in operation in the United States, and in 1900, 35. In 1890 there were 923 wage earners employed in the business, to whom $506,720 were paid; in 1900, 2,471 wage earners, to whom $1,138,420 were paid. The value of the products in 1890 was $2,137,944, and in 1900, $4,579,700.

Glass and Glassmakers.

Glass in Early Times.—Glass was known in Egypt, and was represented on many monuments as early as 1740 B. C. Specimens of glass have been found in the ruins of Egyptian, Assyrian, Greek, Roman and Etruscan cities. The ancients used it for bottles, and all down through the Middle Ages glass was in more or less common use for a variety of purposes. In the fourth century churches had colored glass windows. In 1557 it began to be manufactured in England. Pliny speaks of glass found at the base of Mount Carmel, in Palestine, made by heating sand and salt together.

Glass is a chemical and mechanical product. The essential basis of common glass is silica as the acid element, soda or potash as the alkaline base, and lime and the oxide of lead as the alkaline earths, including baryta and alumina. There is no chemical formula for glass.

The Start of the Industry.—The first known effort at glass making in this country was in 1608, in the colony of Virginia, by a party of eight Poles and Germans, who were brought with the original colonists to make pitch, tar, glass and similar products. They started to work immediately, and sent samples of their skill back to England on the returning ship. It was probably bottle glass, as the window glass used by the colonists was imported. In 1621 funds were supplied in London for the erection of a glass house to make beads for the Indian trade. A few Italian workmen were added. History leaves no record of the progress of the industry until 1787, when 10,000 pounds of glass were exported to England. At that time 500 hands were employed.

Early Factories.—A glass house was erected in Salem, Mass., in 1639, and in 1787 a larger one in Boston. A glass factory was built in New York in 1654, and another a few years later, and still another in 1786. A German built a factory in Salem, N. J., between 1760 and 1765, and ten years later the workmen, on account of its failure, moved to Glassboro, N. J., where are located the Whitney Works, the oldest continuously operated plant in the country. William Penn spoke, in 1683, of a glass factory in Pennsylvania. In 1762 Baron Steigel built works near Lancaster; ten years later another was built in Philadelphia. The glass industry was planted in Pittsburg in 1797, and by 1837 thirteen factories were in operation; in 1857 thirty-three, and in 1865 forty-five, with an annual product worth $6,000,000. Pittsburg has since become the great glass center of the United States, although the development of natural gas in Ohio and Indiana has stimulated great glass-manufacturing enterprise in these States.

Varieties of Glass.—The varieties of glass now manufactured in the United States may be enumerated as follows: Plate glass in several conditions—rough, rolled, ribbed and polished plate; window glass; flint, including table and other glassware, both blown and pressed; bottles and vials, green glass, water glass, incandescent glass.

The working of glass is by blowing, casting and pressing. Varieties of glass may be classified as flat, hollow, pressed and colored. Flat includes crown, sheet and plate; hollow glass includes flint, blown, Bohemian, Venetian, bottle, tube and gauge and slag glass; pressed includes flint, optical, rod glass, marbles and beads; colored includes opaque and enameled, mosaics and hot-cast porcelain, though this definition does not include all varieties.

Natural Gas.—The most important event in the glass industry was the introduction of natural gas as fuel, the first works using it being located at Creighton, near Pittsburg, in 1883. A valuable export trade in glass soon developed, and Pittsburg glass in a few years became known throughout the world. The success of the industry was largely due to the abundant supply of cheap fuel. The first glass works west of the mountains were built by Albert Gallatin at New Geneva, on the Monongahela river, probably in 1797.

Window Glass.—The chief product of the industry is window glass, the use of which has expanded with rapid strides. This glass was manufactured by hand. The workmen inserted the hollow tool into the molten glass, and by rotation attached a certain quantity of the material to the end, then withdrew it, and by blowing through this pipe gradually produced a cylindrical shape, which on cooling was cut lengthwise and subsequently flattened, after which it was cut into desired sizes for packing. Within a very recent period this hand method or "blowing" method has been largely, and soon will probably be completely disused, by reason of the introduction of purely mechanical methods of production. By these methods much larger quantities can be produced and at much less cost. Another less recent improvement was the introduction of the "tank" furnace instead of the "pot," which resulted in very important economies.

Window Glass Production.—There are 100 window glass establishments, with 165 furnaces, with a total pot capacity of 2,429. There are 36 tank furnaces, with a pot capacity of 1,327, and 129 pot furnaces with 1,102 pots. About 75 per cent. of the total capacity is controlled at Pittsburg, the headquarters of the American Window Glass Company. Since 1900 over 600 pots have been built. The average normal consumption of window glass in the United States is estimated at 5,400,000 boxes a year, some of which comes from Belgium. Much glass is produced in the State of Indiana, where there is an abundant supply of natural gas. The raw material of glass making consists of glass sand, soda ash, salt cake, nitrate of soda, limestone, lime, arsenic, manganese, litharge, potash and pearlash, grinding sand and fireclay.

Cut Glass.—The manufacture of glass for surgical, therapeutical and drug purposes has become a very extensive and profitable industry, and is conducted on a large scale in Philadelphia and elsewhere. The "cut" glass industry progresses at slower pace, owing to the excellence of pressed ware, to which it bears a superficial resemblance. The production of glass is now conducted in many States, wherever glass sand and fuel are economically available, and the industry has been much centralized under trusts or large corporations.

Economy of Production.—Calculations which have been made of the cost of production by this process, compared with human blowers and finishers, show that bottles can actually be made at a price of 6 cents per gross, as against $1.50 per gross after the old method. It will produce quart and pint sizes, and experts in glass making believe that it could be utilized in the manufacture of fruit jars, etc., with a few changes.

The greatest advance made in the American glass industry in the past decade has been in melting furnace, in the substitution of the tank for the pot furnace and the open pot furnace for window glass, bottles and jars, and which vary in length according to the number of pots, usually from 6 to 10, placed in two rows. In the regenerative gas-fired furnace, the regenerators are so placed that in the event of a pot breaking the molten glass cannot reach them and obstruct the draft. The first successful gas-fired glass-melting pot furnace was developed abroad in 1861. The application of gas is one of the chief improvements in modern glass making.

Plate Glass. — The introduction of a device known as the continuous lehr for the annealing of plate glass was an epoch in the industry. It displaced the slower and more expensive annealing-kiln system. Previous to the introduction of the lehr, the annealing of plate glass was done in a tedious manner. Some annealing lehrs average about 200 feet in length, and start from the casting-table as a continuous connected series of five kilns; the whole of the interior of the lehr in a first-class plate-glass factory is brilliantly lighted by electricity, and the heat is controllable to the utmost nicety by the use of pyrometers. The plate passes from station to station through decreasing temperatures for a period of three hours, when the annealing process is complete and the plate is ready for the grinding process, as against three days by the old system of annealing.

The American Plate Glass Company have a lehr which is working satisfactorily with plates of from 75 to 80 square feet.

Plate Glass. — The manufacture of plate glass was attempted at Cheshire, Mass., in 1852, and a later attempt, in 1856, was made at Lennox, Mass. In 1865 the invention of a polishing plate firmly established the industry. The first pronounced success was in 1869, at New Albany, Ind., and works were afterward established at Tarentum, Pa.; Louisville and Jeffersonville, Ind.; Crystal City, Mo., and elsewhere.

The Marsh Table.—The Marsh patent table is a valuable device for reducing the temperature of the glass while being ground and polished, by the circulation of a constant flow of water under the table. This cooling device permits the operation of the grinders or polishers to be conducted at a much higher rate of speed than without it. The transfer table is movable, thus making it possible to grind and polish one side of a plate without turning it.

Larger Sizes and Better Quality.—All of the improvements made in the manufacture of plate glass during the past twenty-five years have been for the purpose of increasing the size of the plates and the quality of the glass. The liability of breakage during the finishing process has resulted in a very great reduction in the average size of finished plates. In the manufacture of plate glass the use of tank melting-furnaces in connection with fining-pot furnaces will soon appear under the stimulation of necessity and spur of invention, and then the size of plates cast will be regulated at will. The introduction of the continuous lehr has largely reduced the high ratio formerly existing between the cost of construction and the capacity of plate-glass factories.

Cathedral Glass.—The quality of cathedral glass, which is largely manufactured in the United States, has been brought to such perfection that not only has the domestic market been freely supplied, but a valuable export trade has been developed in Europe. Europeans acknowledge the superiority of our colors, and this glass is in demand in leading foreign art centers.

Wire Glass.—Wire glass is made by casting two sheets of glass with a wire net imbedded between them, and it is found to be a perfect fire retarder. It is specially adapted for partitions, fire shutters, skylights and glazing in all places subject to the stress of storm or fire.

Skylight Glass. — Skylight glass is made in plate-glass establishments, and much of it is shipped to Europe. The production of bent glass for store fronts and show-cases is also an important item. Within a few years the manufacture of tile glass has been introduced on an extensive scale. It is used as a sanitary protection for walls, ceiling and floor material.

Opal Glass.—Decorated opal or porcelain glassware, made into small piece sets in an endless variety of novelties and toilet articles, is coming into increasing favor.

Pressed and Blown Glassware. — Pressed and blown lead and lime glassware manufactured in the United States is characterized by purity of color, excellence of design and finish and cheapness of cost. It is based upon the idea of pressing molten glass into any desired shape. In 1864 a method was discovered for making lime glass to rival in purity and brilliancy the most expensive lead glassware that had been made. It was made by the substitution of bicarbonate of soda for soda ash and a better proportion of the materials in the vats. The ornamental articles which are manufactured of lime glass equal in beauty the finest lead glass.

An epochal event in the glass industry was the invention of the pressed glass process. The first article was a tumbler made at Sandwich, Mass., by a machine invented by a carpenter, and first exhibited at the Philadelphia Centennial Exhibition. This process resulted in the economical production of an amazing variety of work, and enabled manufacturers to offer for common use glassware of a grace of form and beauty of design which formerly only the wealthy could enjoy.

The pressed-ware trade has been strengthened by increased rapidity of production by the use of the improved press and continuous tank. These improvements have increased the production of common tumblers and jelly glasses, cheap unfinished tableware and common lamps. By the tank process very much larger quantities of glass are transformed into products in a given time.

Tumblers. — Thin blown tumblers have been made by machinery for many years, also lamp chimneys. While the high-speed machine is a success in ordinary ware, both pressed and blown, the manufacture of high-grade ware still requires the sympathetic touch of the skilled workman.

Factory Improvements.—Great strides have been made in the improvement of factory equipment for handling glassware. Lehrs are operated by electricity, electric conveyors take the ware from the lehr to the packer, and then to the stockroom or car. Finishing operations have also been greatly improved. The manufacturer of pressed and blown shades, globes, electric bulbs and glassware for gas and electric lighting rank third in this branch of the industry. Although the increased use of gas and electricity has curtailed the use of the oil lamp, there is a growing tendency toward the use of fancy lamps with highly decorated or ornamented shades and globes, which is stimulating this branch of the industry to produce work of high artistic merit.

Latest Bottle Machine.—The latest automatic bottle-making machine, known as the Owens machine, is mounted upon a traveling platform, which allows it to be moved at the will of the operator by means of an electric motor with which it is connected. Adjacent to it is a tank furnace, as well as an annealing oven. Although the apparatus appears somewhat complicated, its operation is comparatively simple. Taking the molten glass from the continuous tank which serves it, it gathers its glass, forms the blank, transfers the blank from the gathering to the blow mold, then blows the bottle. Each machine has a capacity for gathering and blowing nine pint or quart bottles every minute. As fast as blown, the bottles are delivered to the annealing oven by means of an automatic conveyor, adjusted so that it takes away the product as fast as manufactured. As is well known, the majority of bottles now manufactured by hand require extra processes in order to finish them at the lip and neck, for which small furnaces, heated by oil or gas, are used. This mechanical bottle-maker, however, finishes the ware so completely that none of the extra labor referred to is required, as the blank bottle comes from the gathering to the blow mold with lip and ring already finished. As it can be worked continuously, a single machine has a capacity of nearly 13,000 bottles every twenty-four hours.

Tank Capacity.—The glass-melting capacity of continuous tanks is about one-half the total glass-making capacity of the United States. In 1900

4,300 pots were in action. Day tanks of a capacity equivalent to 818 pots, and continuous tanks of a capacity equal to 3,775 pots, were also reported. The window tank is oblong—four or five times as long as the width—with a capacity varying from 18 to 60 pots. A modification of the continuous tank for window glass, styled a blow-over tank, was introduced in 1900, which possesses several advantages, and the results obtained will probably lead to its general introduction. It acts as a fuel-saver, and the heat is more constant and uniform than with a blow furnace.

An Immense Window-Glass Plant.—The American Window Glass Company added, in January, 1904, ten additional mechanical blowers to their plant at Hartford City, Ind. Each machine has an output equal to that of eight blowers, eight gatherers and eight snappers. The sixteen machines in place at that date had 108 pots' capacity. At an estimated cost of $20, six of these machines, on a test, made, in fourteen hours, 1,444 20-foot rollers and 100 pieces which, when cut, made over 200 boxes, which represents the labor of three workmen for a month, resulting in an estimated reduction in labor cost on this amount of work of about $300.

At first glance this remarkable invention might appear to be able to undermine the value of the glassblower and to threaten remunerative wages; but no such ruinous consequences have as yet overtaken the wage-workers in any branch of industry, and it is not probable that the glassblowers will suffer from glass-blowing machinery.

Comparative View of the Glass-making Industry in the United States.

	1880	1890	1900
Number of establishments	211	294	355
Capital invested	$19,844,699	$40,966,850	$61,428,903
Wage-earners	24,177	44,892	52,818
Wages paid	$9,144,100	$20,855,961	$27,084,710
Value of product	$21,154,571	$41,051,004	$56,539,712

Glass Staining and Ornamenting.

Staining.—The painting, staining and ornamentation of glass has for centuries engaged the attention and study of artisans. The magnitude of the industry in the United States is represented by a value of products exceeding $8,000,000 annually. Stained glass is glass on the surface of which patterns and figures are painted with mineral pigments, and afterward fused and fixed by the application of heat. Glass painting is somewhat analogous to, but is distinguished from glass staining, the former having a design painted upon it, with colors burned in. The latter receives its color in the process of manufacture, or the separate pieces are colored after having been cut the required shapes out of white glass. In one case it is the painting of enameled colors on sheets of glass, in the other it is a painting made up of pieces having the required colors fitting together and held by leaden cames.

Methods. — There are four methods: (1) The mosaic, the earliest; (2) the mosaic stain; (3) the enamel; (4) the mosaic enamel. In the mosaic stain, the window is made up of detached pieces, as in the mosaic; the shades are given by a stain of brown, which seems to have been the first color which the artists succeeded in firing on to the pieces of glass. In the enameling process, all the required colors are painted upon the same piece of glass and fired in the kiln, producing the effect of an oil painting. In the mosaic enamel process, colored glass is used as a groundwork to paint on, instead of on white.

Various Processes. — Among the processes to which glass is subjected are etching, drawing, frosting, gilding, platinizing, silvering, stenciling, lacquering, engraving, enameling, ornamenting, staining, coating metals and many other processes. The fundamental process is virtually the same. The almost innumerable processes employed are the result of long investigation and experiment. One method of ornamentation is effected by a machine which causes the vessel, attached to a blowpipe, to revolve more evenly and rapidly than can be accomplished by unaided and individual skill.

If a bulb of molten glass be rolled upon variously colored powdered glasses, flakes of mica or leaves of gold, silver or platinum, it will adhere to it, and by continuous rolling will amalgamate.

Another Method.—Glass may be stained by painting its surface with a fusible colored glass, ground to a fine powder and mixed up with gum water or turpentine, and after drying, heating the painted glass in a furnace until the coating fuses. A colored wash for white glass may be made of collodion, shellac or spirit copal varnishes, colored with one of the coal-tar dyes.

Pigments.—The pigments commonly employed for decorating glass and porcelain have been prepared either by melting metallic salt in rosin or by decomposing soluble rosin soaps with the solutions of these salts, forming an insoluble resinate, which is first dried, then dissolved. With carbolic acid these pigments can be easily prepared.

GLASS INDUSTRY.

	Nº OF ESTABLISHMTS	WAGE EARNERS	WAGES PAID	VALUE OF PRODUCTS.
GLASS.	355	52,818	$27,084,710	$56,539,712.
GLASS, CUTTING & ORNAMENTING.	417	4,931	$2,403591	$8.776.006.

WHAT GLASS IS MADE OF.

CENSUS REPORT.

COST AND QUANTITY OF MATERIALS.

NITRATE OF SODA 10,770 TONS $320,937.

GLASS SAND. 581,720 TONS. COST $846,822.

SODA ASH. 157,779 TONS. COST $2,259,939.

SALT CAKE 53,257 TONS. COST $518,590.

LIMESTONE 91,015 TONS COST. $181,717.

ARSENIC 2,349,261 lbs. COST. $112,630.

LIME 794,679 cwts. COST $147,901.

MANGANESE 1,493,538 lbs. COST $57,493.

LITHARGE 8,386,106 lbs. COST $490,200

POTASH 4,406,211 lbs. COST $186,847.

GRINDING SAND 265,438 TONS. COST $166,040

FIRE OR POT CLAY 32,151,017 lbs COST $221,183

POTS NOT MADE AT WORKS Nº 8,941 COST $381,147.

FUEL COST $3,203,146

PACKAGES AND PACKING COST $4,913,544

ALL OTHER MATERIALS COST $2,722,873.

TOTAL COST $16,731,009.

Enameling.—Enamel paints for glass are variously made. The early enamelers ground up some of the glass they were using and the glass to which it was applied at the actual melting heat of the glass; but now the paint is "fixed" by using glass much more fusible than the glass used for glazing. This may be had by using borax in the fluid glass.

Etching.—Glass is etched by hydrofluoric acid; the glass is warmed, not enough to melt the wax, then covered with a layer of white wax by rubbing it on; when cold, the design is cut out of the wax with a graver. Photographs can be etched on glass. Any photographic film will protect the glass where the etching is not to act. Designs or pictures may therefore be easily formed, capable of resisting the action of hydrofluoric acid. Glass which is faced with a surface of color or opal may be worked with great ease, and the acid, coming in contact with the unprotected surface, dissolves away the facing and leaves either a design in the transparent glass or one in color, according as a negative or positive has been made use of to produce the mask upon the glass. A dilute acid is employed for etching in preference to a strong one.

Comparative Summary of the Glass Cutting and Staining Industry.

	1880	1890	1900
Number of establishments...	170	279	417
Capital invested............	$945,180	$2.504,089	$4,019,534
Wage-earners	1,586	3,320	4,931
Wages paid..................	$706,768	$1,954,560	$2,403,591
Value of products...........	$2,535,009	$6,090,378	$8,776,006

Gloves and Glove Manufacturers.

Early Uses of Leather.—Leather constituted a part of the dress of the human family from time immemorial. It formed a part of the costume of prehistoric cave-dwellers. Leather was known to the earliest nations, and its manufacture was developed by the Persians, Greeks and Romans. Its use was confined mainly to the higher orders, particularly to the clergy and the military. The early literature of the Anglo-Saxon race contains frequent allusions to its use. During the Middle Ages it formed a part of the regalia of kings, princes and their attendants. It was said by an old proverb, for a glove to be good three nations must make it: Spain to dress the leather, France to cut it and England to sew it.

Gloves as Regalia.—Charlemagne, about the year 790, allowed the monks in certain districts in his dominions to hunt, to obtain skins for gloves and girdles and to cover the books which they wrote. For centuries the glove continued to be an essential adjunct to the regalia of royalty, and was particularly worn at the coronation of kings and at their funeral ceremonies. Gloves were also worn at the consecration of bishops, and were placed on their hands at burial. Their use and elegance, however, became so extravagant that the Church was compelled to pass sumptuary restrictions limiting their use, as a restriction to vanity. The Germans were probably the first to adopt the custom of wearing gloves for common use. Those worn by ladies were of fine material and workmanship, usually adorned on the back with a number of stones or jewels.

Gloves in England.—In England gloves were introduced as ornaments by the Normans, and in the fourteenth century they were adopted by ladies of rank. The cheveril gloves were in common use in the sixteenth century, and were made from the skin of the French goat, which was called chevre. By 1550 the manufacture of gloves had been so cheapened that they were used by all classes and conditions of men. The cuffs were frequently adorned with magnificent embroideries for the use of royalty, ornamented with flowers, butterflies and even a little goldfinch in the middle. Fine silk was used to furnish a wide range of colors. The entire length of the glove was 13 inches, of which the cuff was 4½ inches, often lined with crimson silk and with side-bands of cloth-of-gold ribbon edged with gold fringe.

Gloves in Ireland and France.—In Ireland the glove industry early developed, and the Limerick glove, made from the skin of a very young calf, lamb or kid, was of exquisite texture. One of these gloves could be placed within a walnut shell. In France the glove industry was conducted at Paris, Grenoble, Nicot and Montpelier.

Gloves in the United States.—The industry was established in the United States about 1760, near Fulton, New York. The first gloves made were really mittens, and a large trade was soon established for them. In 1825 Elisha Johnson, of Gloversville, N. Y., carried a load of gloves to Boston in a lumber wagon, making the journey in six weeks; the gloves created quite a furore in Boston society, because of their fine quality and home origin.

The Sewing Machine in the Glove Industry.—The sewing machine revolutionized glove making. The first sewing machines were used only in the stitching of the thin binding on the tops of gloves and mittens. In 1854 a machine was introduced to stitch the laps and bindings, and in 1856 a machine was introduced which made light goods throughout. The wax thread was used in 1858. Steam power was introduced in running sewing machines in glove making in 1875.

Skins Used.—Many varieties of skins are now used which for a long time were thought valueless. The deer-skin glove early became a favorite. Buckskin in its various forms was used for heavy gloves. The finer gloves for street wear are made from skins of the goat, kid, lamb, antelope, calf, colt, Arabian sheep, South American kid, chamois and reindeer. Deer skins are largely supplied by Mexico, Central and South America, and to some extent by the United States. The skin of the mocha, a sheep found in Arabia and Abyssinia, is also much used.

Tanning of Skins.—Early in the history the tanning of skins for gloves was done by using the brain of the deer; later, the brain of the hog was used. At the present time sheep and lamb skins receive what is termed "salt pickle," and are placed in an alum bath for twelve hours. They are then "staked," which consists of drawing the skin over a thin round face iron, partly by the hand and partly by the knee of the operator; hence the term "knee staking." The various processes to which this leather is subjected are complicated and interesting.

Comparative Statement of the Glove and Mitten Industry.

	1880	1890	1900
No. of establishments	300	324	397
Capital Invested	$3,379.648	$5,977,820	$9,089,909
No. of Wage-earners	7,697	8,187	14,345
Wages paid	$1,655,695	$2,670,344	$4,182.518
Value of products	$7,379,605	$10,103,821	$17,048,656

Of the above, in 1900, the leather glove industry represented a value of product equal to $16,721,234, or 98.1 per cent. of the entire output.

Glove and Mitten Making.

Materials Used.—The making of mittens, while not a distinct branch of the greatly diversified textile industry, is an important one nevertheless. Tans, including all kinds of domestic sheep skins, form the principal material from which mittens and gloves are manufactured. The mochas are largely used, as well as horse and cow hides and deer skins, also the skins of seals, hogs and dogs. Mocha and imported kid are used for men, women and children; fine lined and unlined are made into gloves and mittens. Deerskins are cut into men's gloves and mittens, while horse and cow hides and goat and seal skins are used as a substitute for deer skins in men's imitation mittens and buck gloves. It is only recently that silk linings of the highest grades have come into use.

Made at Home.—During the early history of the industry of the United States, mittens only were made about the year 1810; the demand for gloves developed soon after. They were made at first in families and not in factories. The maker threaded a square-pointed needle with heavy linen thread, double tied a knot in the end, waxed it and placed a strip of buckskin between the edges as a welt, and sewed up the seams.

On the introduction of the sewing machine nearly all the operations of mitten and glove making were turned over to these machines and the industry expanded steadily.

Present Demand.—Mittens continue to be largely made, but mostly for feminine requirements, and are made of silk, lisle thread, cotton and wool. The extent of the mitten industry itself cannot be separately known as the statistics are combined with glove making. The totals of both are shown in the following figures:

Comparative Summary of the Glove and Mitten Industry.

	1880	1890	1900
Number of establishments	300	324	394
Capital invested	$3,379,648	$5,977,820	$9,089,909
Wage-earners	7,697	8,187	14,345
Wages paid	$1,655,695	$2,670,344	$4,182,518
Value of products	$7,379,605	$10,103,821	$16,926,156

Glucose Manufacture.

Glucose is a variety of sugar occurring in nature very abundantly, as in ripe grapes and in honey, and is produced in great quantities from starch and other vegetable products by the action of heat and acids. It is only about half as sweet as cane sugar, and is known by various names, such as dextros, grape sugar, diabetic sugar and starch sugar. It is obtained as an uncrystallized residue in the manufacture of glucose proper, and is used as a cheap adulterant of syrups, beers, etc. The industry is limited to 7 or 8 large establishments at the present time, which employ over 3,000 workmen, whose wages amount to about $2,000,000 annually. The capital invested at the present time amounts to $40,000,000, in round figures, and the value of the output in 1900 was $21,693,656, or three times the amount ten years previous, or an increase of fivefold over the production of 1880.

Glue and Mucilage Making.

Process of Making.—The substances designed for glue making are usually macerated with milk-of-lime for fourteen days and dried by exposure to the air. This process is repeated and then the substances are submitted to various operations. Powdered chalk, brick dust or sawdust added to glue makes it hold with more than ordinary firmness.

Common Glue.—Common glue is extracted from horns, hoofs and cuttings of the hides of various animals. In the smaller plants the materials are first steeped in water, then boiled to the consistency of a thick jelly, passed through ossier baskets, then poured into flat frames or molds and then cut into pieces.

Elastic Glue.—Glue loses much of its strength by being melted often. Elastic glue is made by dissolving glue in a water bath and evaporated to a thick fluid to which equal weights of glycerine are added, evaporation and stirring continuing, when it is run on a marble slab to cool.

Glue-Making Materials. — Glue is an inferior grade of gelatine, and it is largely used as "sizing" in textile, paper and allied industries. The best glue-making material is the corium or true skin of the animal, which lies under the outer skin or epidermis. Glue extracted from bone is less adhesive. The raw material of most glue factories consists of the waste of slaughter houses and leather factories, but the slightest trace of tannic acid renders the material useless.

Process.—Glue made from hides is limed for from 10 to 40 days, or caustic soda may be used. Heat is then applied in the later processes by the use of steam in closed or perforated pipes, or it is blown by high pressure directly into the vessel containing the mixture. After boiling, the glue settles or is strained through linen bags. The waste is used as fertilizer. Formerly this product was dried in the open air but now the glue is dried in rooms under controlled humidity and temperature, in shallow wooden molds. It is then cut on smooth, moistened tables by wires.

Bone Glue.—Bone glue is made by boiling bones after the removal of the contained calcium phosphate by hydrochloric acid.

Liquid Glue. — Liquid glue is made by using nitric or acetic acid to form a solution of glue.

Great Plants Have Their Own Methods.—In the greater glue-making establishments of the United States independent and original processes are adopted as the result of long and practical experience, by which numerous economies are subserved and the country is supplied with all manner of glue products at prices which the smaller and cruder factories are unable to meet.

Mucilage.—Mucilage is largely used for labels, which is made by macerating gum in water in certain proportions, then adding rock candy and gum arabic. Artificial or British gum is made of crush malt and potato starch mixed with water and raised to the boiling point.

Processes.—There are many processes for mucilage making, all of them depending upon the use of fundamentally similar material, subjected practically to like processes. It is made of various vegetable gums or of dextrin. It is also made by dissolving gum arabic in hot water, filtering the solution and adding some antiseptic to prevent fermentation and the formation of mold.

Comparative Summary of Mucilage and Paste Industry.

	1880	1890	1900
Number of establishments...	4	55	117
Capital invested............	$3,100	$748,826	$1,265,426
Wage-earners................	9	309	480
Wages paid..................	$3,090	$119,782	$295,082
Value of products...........	$16,700	$1,276,611	$2,629,299

Comparative Summary of the Glue-Making Industry in the United States.

	1880	1890	1900
Number of establishments...	82	62	61
Capital invested.	$3,916,750	$4,859,266	$6,144,407
Wage-earners................	1,801	1,697	1,618
Wages paid......	$600,018	$676,089	$685,096
Value of products...........	$4,324,072	$4,270,460	$5,389,006

Gold-Beating Industry.

Facts and Figures.—A single grain of gold can be drawn out into a wire 500 feet long, which is sufficient to gild over two miles of fine silver wire; a grain can be beaten out to cover $56\frac{3}{4}$ square inches. Ordinary solvents do not affect it. It forms two salts—aurous and auric. It is rendered brittle by tin or antimony. It is used medicinally in scrofula. The world's production of gold in 1903 was about $327,000,000, and it is estimated that it may reach $400,000,000 in 1904. Its abundance as the basis of a circulating medium is a most powerful stimulant to commerce and trade, by reason of its value as a medium of exchange. Gold was first coined in England in 1257. The standard of coinage in the United States, France and Germany is 9 parts gold to 1 of alloy. In England the standard is 11 parts gold to 1 of alloy.

Gold Beating.—Gold for beating is made by adding a small percentage of silver and copper, to the extent of 1½ per cent. The ingot is rolled into a ribbon between rolls to $\frac{1}{800}$ of an inch, equal to a surface of 500 square inches to an ounce of gold. It is then cut into pieces of about an inch square, placed between pieces of gold-beaters' skin four inches square, and beaten with a ponderous hammer on a smooth marble slab until the gold has thinned and expanded to the size of vellum. Each piece of gold is then again divided into four, placed between pieces of gold-beaters' skin as before, and again beaten until it expands to the size of the skin. A third and a fourth beating follow, until the gold has been reduced to the necessary thinness. The hammers vary in heaviness.

Statistics.—The value of gold and silver leaf and foil produced in the United States in 1900 was $2,666,224, compared with $3,977,791 in 1890 and $1,614,040 in 1880.

Gold, Civilization and Prosperity.

The World's Gold Supply.—By way of showing the growth of the gold supply of the world for over 400 years, the following figures are appended:

World's Gold Production per Year.

1493	$4,000,000
1545	5,656,000
1600	4,905,000
1650	5,828,000
1700	7,154,000
1750	16,356,000
1800	11.823,000
1850	84,845.000
1900	200,000,000
1901	260,877,420
1902	295,412,700
1903	327,049,750

Of the amount for 1902, the United States produced $80,006,000, and slightly more for 1903.

Methods of Extraction.—Gold is extracted from its ore either by direct washing or by combining it with mercury, lead, silver or copper, or by bringing it into aqueous solution. Extraction by washing is done only when ores carry natural gold, of which fanning is the swiftest method.

The Dry Process.—This process consists in alloying the gold with lead and cupeling. It may be done by introducing ores in a bath of lead.

Amalgamation. — Amalgamation consists in combining the gold with mercury. Amalgamation without previous crushing of the gold-bearing material is practiced with auriferous sands and gravel, and was extensively used in some parts of California. In most cases gold-bearing ores are crushed in stamp mills and a portion of the gold is caught by the mercury in the stamp boxes.

Aqueous Solution. — Two methods prevail for obtaining gold by aqueous solution, viz.: the Plattner or chlorination process and the McArthur-Forrest or cyanide process. The chlorine process consists in calcining the ore, which converts all the metals except gold and silver into oxides. Chlorine gas is then applied to the calcined ores in vessels, resulting in the formation of chloride of gold, which is leached out of the ore by means of water. Sulphate of iron or charcoal in them precipitates the gold.

Cyanide Process.—In the cyanide process the crushed ore is treated with a solution of potassic cyanide. Zinc then precipitates the gold.

Silver.—As much gold ore contains silver, their separation becomes an important matter. There are three methods, the dry way, the wet way and by electrolysis.

In the dry way silver is converted into a sulphide or chloride and thus parts company with gold. In the wet way nitric acid is used in which silver is soluble and gold is not.

The Electrolytic Process. — In the electrolytic process silver passes from the anode, which consists of a bar of gold-silver alloy to the cathrode when the two poles are immersed in an acidulated solution of nitrate of silver. These two latter processes are generally used. About one-fourth of the annual production of gold is employed in coinage; the rest is absorbed in the arts.

Power of Gold.—The relation between the volume of gold and the prosperity of the people of the world has always been a subject of study by economists and statisticians. The more gold the greater the prosperity is their philosophy reduced to a nutshell. It was only a few years ago that even the United States passed from possibilities of a dual medium, with its attendant uncertainties, and still more recently the lesser nations of the globe have transformed their financial systems to a gold basis.

Gold and Prosperity.—If the volume of gold has a direct bearing upon national prosperity, the people of the United States have the force of that reason for anticipating a prolonged period of activity. Apparently it is a fair contention to make, that an abundant supply of an unfluctuating medium of exchange is a source of industrial and commercial power, as well as of enormous activities. The ratio of increase in the gold supply of the world has been practically as 20 to 30 and 33 during the past three years. At this ratio of increase in two years the world's annual supply of gold will exceed $400,000,000 annually. These figures therefore seem to indicate a long period of activity, though the gold factor alone does not solve the problem of prosperity. Overproduction of commodities has wrought commercial disaster in the past periodically.

Control of Competition. — The organization of industrial, capital and commercial forces into huge trusts has, it seems, apparently brought about one permanent improvement, namely, the control of competition and the keeping of competition within reasonable limits where enlightenment and Christian brotherhood will guide our activities instead of a blind and half insane rush of production controlled by a larger number of incompetent business interests. The mighty centralization which has been effected through the agency of trusts and combinations is acting in a disciplinary manner over all the business interests and is preventing thousands of business men who know how to manufacture, but who, perhaps, do not know how so well to practice far-seeing commercial oversight, to keep from doing themselves harm and upsetting that harmony of interest and evenness of expansion and solidarity of interests which should be ever kept in sight and which can be maintained if only reason, experience and wisdom prevails. Of course, the centralized powers are conducting their vast combinations for the greatest profit and to secure the greatest possible control irrespective of the public good, but it seems to be so ordained in the nature of things that even selfishness is made to serve the great ulterior purposes of good.

Greases and Lubricants.

Purpose of Lubrication.—Lubricants constitute a very important factor in machinery, the use of which greatly subserves industrial requirements. In practically all mechanism parts rub against or over other parts, and hence the necessity of some material which, while not offering any recognizable resistance to the mechanical action of the parts of machinery, will prevent destructive friction. Heat disintegrates and crystallizes, as well as expands the parts, and in such expansion, especially where, from the nature of the parts of the machinery, it is unequal, obstructs free and necessary action. In fact, without proper lubrication, machinery would be racked to pieces.

Kinds of Lubricants.—The kinds of lubricants for the varying requirements call for special care not only of the material itself, but care as to the material from which it is made.

Essential Features.—The essentials of lubricants are sufficient "body" to keep the surfaces from coming into contact, minimum of friction, greatest safe fluidity, maximum capacity for receiving and distributing heat, freedom from tendency to gum or oxidize, absence of acid, high vaporization and decomposition temperatures and low solidification temperatures, and freedom from foreign matters.

The Best Composition.—It is the conclusion of experts that the safest, most efficient and most economical lubricants for all manner of bearings are produced from a judicious mixture of animal or vegetable with good mineral oils.

Comparative Summary of Lubricating Industry.

	1880	1890	1900
Number of establishments...	156	233	289
Capital invested............	$2,566,779	$4,336,193	$7,080,692
Wage-earners...............	1,091	1,470	2,046
Wages paid..................	$556,015	$763,888	$1,069,683
Value of products..........	$13,730,003	$7,474,911	$11,669,821

Grindstones, Making of.

Grindstones in the Industries.—Grindstones constitute a very important feature in a large number of industries; during the past decade the production increased fivefold. Grindstones have been used in all ages, and perhaps were the earliest instruments used for grinding and sharpening when population began to gather into communities. Their use is frequently referred to in the old books as means for sharpening and polishing tools and grinding grains. New methods have been more recently introduced which lessen the dependence on this original method of grinding.

Material and Cost.—Grist mills and many others of the lesser industrial establishments making use of grindstones and the modern appliances for their propulsion, have made them increasingly valuable as industrial appliances. One-half of the cost of production is in wages paid to labor. The raw material is cheaply and easily obtained, although it requires quite an expert eye to detect those qualities of stone which are most serviceable for the purposes to which grindstones are subjected.

Comparative Summary of the Grindstone Industry

	1880	1890	1900
Number of establishments...	14	9	25
Capital invested.	$125,261	$75,750	$903,748
Wage-earners..	231	124	1,167
Wages paid..................	$57,040	$51,776	$407,153
Value of products...........	$184,555	$122,240	$1,088,909

Guns and Gunnery.

Science of Killing by Machinery.—The science of killing people by machinery has been developed to a high state of perfection in this Christian country. There are 278 patents for breech-loading mechanism alone, 70 patents for compressed-air ordnance and 4715 patents for firearms. There are also 880 patents for projectiles of various kinds.

Improvements in Breech Locks.—An important improvement in breech locks consists of a single movement of the lever to open or close the breech, the expended shell being expelled by the same mechanism. By far the most popular principle of the breech lock is that known as the interrupted thread, in which the plug, when closed, has its axis in alignment with the axial bore of the gun. Its threads are interrupted by longitudinally arranged channels, and the breech of the gun has corresponding threads and channels. In one form or another this construction enters into almost all modern breech mechanisms, among which are the Driggs-Seabury, the Dashiell and the Vickers-Maxim.

Rapid-Fire Guns.—Rapid-fire guns represent the most modern form of modern ordnance. These small guns throw a shell six miles, and the striking energy of their projectiles at the muzzle is equal to the penetration of iron plate 21 inches thick or steel 16 inches thick. When the gun is loaded it is held in the forward position by coil springs inclosed in cylinders and holding a recoil seat for the trunnions, and also has two pistons traveling in cylinders filled with glycerine. When the gun is fired the recoil causes it to slide back, carrying the pistons, and the recoil is checked by the resistance of the glycerine traveling through an opening past the pistons. After full recoil, the gun automatically returns to its former position. The disappearing gun was invented in 1835; further improvements followed one another in succession. The machine gun of Dr. R. J. Gatling made a commotion in the world when it appeared. In it the cartridges are automatically and successively fed into the chambers of the barrel, and its several hammers are so arranged in connection with the barrel that the whole operation of loading, closing the breech, discharging and expelling the empty cartridge cases was conducted while the barrels are kept in a continuous revolving movement, by turning the hand-crank.

Dynamite Gun.—The next powerful gun was the Zalinski dynamite gun, introduced in 1889, which covered a method of exploding a charge of powder in one gun barrel and causing it to compress the air in front of it and force it into another barrel behind the dynamite cell, so that this relatively cool body of air is interposed between the hot powdered gases and the dynamite.

Ordnance Making.—The science of ordnance making now avoids the former necessity of cutting away 50 per cent. of the thread of the breech closure. In an improvement of May 1, 1900, the entire thread is retained, thus reducing the weight and length of the breech-block without weakening the breech closure. It is now proposed to make heavy ordnance purely automatic, whereas heretofore six-pounders have been the largest to which the automatic principle has been applied.

Formerly the firing mchanism was automatically cocked by the opening of the breech. It was necessary to reopen the breech to recock in case of failure to fire, which would be a dangerous operation. It is now proposed to use a firing lever, a pull of which first arms the main-spring, then releases the firing-pin or hammer, and on release is automatically reëngaged for another pull without disturbing the breech mechanism.

The Pneumatic Gun. — The pneumatic gun, which was once highly regarded, has been superseded owing to the development of high explosives for charging shells which are insensitive to the shock of the gun discharged.

Gas Checks.—Valuable improvements have been made in gas checks for ordnance, whereby the full force of the powder is directed against the base of the projectile.

Gun Mounts.—Advances have been made in the manner of handling the gun, in its elevation and depression, and to enable it to take up its recoil on firing. The gun on recoil is caused to travel in the arc of a circle and to disappear behind embrasures or to be lowered into a pit. These appliances are considered of great value in gunnery.

To Offset Rolling and Pitching.—Another invention automatically maintains a gun in an absolute position regardless of the rolling of the gun platform in a seaway. A device is in drill use which imitates the rolling and pitching of a naval gun platform, for the practice of gunners in port or ashore. A number of improvements in mounts for disappearing guns has recently appeared.

Hoisting Ammunition. — Numerous improvements have been made in ammunition hoists, by which ammunition is kept close at hand from the magazine. Geared rammers are superseding hydraulic rammers. There are also remarkable improvements in automatic range-finding sights which work on a vertical base-line, and which are improvements on older methods.

Firearms.—The improvements of recent years in firearms involve greater rapidity of fire, a flatter projectory, increased effective firing distance, greater penetration of bullet, decreased weight of gun, a smaller caliber and a lighter projectile. The devices for operating the firing of small arms have also taken a new departure, in which breech mechanism is manipulated by the recoil of the gun against the shoulder, to fire it, to expel the expended cartridge-shell, to withdraw a fresh cartridge from the magazine in the gun and to place it in position in the barrel of the gun for another discharge. This operation is automatically repeated until the last cartridge in the magazine is exhausted.

Explosion of Gas in Breech Mechanism.—Another novel means of firing small arms has been developed, consisting in the use of the explosion of gas to operate the breech mechanism. Others are operated by an electric battery in the stock, the cartridge being exploded in closing the circuit by a pull of the trigger. Compressed air and also liquefied carbonic acid gas have been utilized as a motive power to operate the breech mechanism of small arms to great advantage.

Novelties.—Novelties have also been patented which involve means for discharging in alternative succession two barrels of a double-barreled fowling-piece, and which supplant older methods.

Single Trigger.—Inventions in single-trigger mechanism have been directed to overcoming the liability of firing the second barrel by the involuntary pull following the first discharge. There are convenient devices, also, which consist in a clip or packet adapted to hold a few cartridges, which may be inserted in the magazine of a gun, so that when the magazine is exhausted a fresh supply may be ready for use.

Patents.—There are 687 patents for explosives. Most of the smokeless powders contain nitrate cellulose and nitro-glycerine, or both, rendered plastic, coherent, homogeneous and convertible into hard, horny rods or into grains of free-running powders.

Projectiles.—The recent improvements in projectiles overcome the danger of premature explosion due to the shock of concussion created by the change of a mass of powder from a solid form to that of a gas, for the propelling of the projectile from the gun.

Penetration.—Improvements have also been made which enable projectiles to penetrate armor plate without fracture. The very best armor plate yet made has been successfully pierced by projectiles. Shells carrying high explosives are made to penetrate the best armor plates and to explode after penetration.

Shell Fuses.—A notable advance has been made in safety devices for shell fuses, by which an accidental explosion of the detonator is rendered harmless.

A Better Arm Wanted.—The greatest efforts of inventive talent are now being directed to the production of a superior firearm which will be effective at long distances beyond the limits of sighting. The Krag-Jörgensen gun, adopted by the United States Government, and the Lee, adopted for the navy, are both magazine guns, although of different types and of different caliber. All the greater governments of the world are, through their experts, making most strenuous efforts to devise firearms that will render each superior in attack to enemies.

The New Springfield Rifle.—The new Springfield rifle now (1904) being issued to the United States army is conceded to be the most serviceable and most powerful military rifle in the world. It embodies the best features of the Krag-Jörgensen and the Mauser rifles, and weighs 9.47 pounds, against 10.64 pounds for the Krag, and its barrel is 24 inches, while the Krag is 32 inches. Over all, the new piece measures 43 inches, against 49 inches for the Krag. The bullets for both rifles are the same, while the charge of smokeless powder in the Springfield is 43.3 grains, against 37.6

for the Krag, which gives the former a muzzle velocity of 2,300 feet per second, which is 300 feet per second faster than the Krag, and a greater muzzle energy, in the proportion of 1,952 foot pounds to 2,582. The new Springfield has a range of 5 miles, and can be sighted 3,000 yards, or nearly 2 miles. At 1,000 yards a line of men resembles a broad line; at 1,200 yards cavalry is distinguished from infantry; at 2,000 yards bodies of troops can be distinguished. At a distance of 53 feet the new Springfield has penetrated 54.7 feet of pine boards, and 6.3 feet at 1,500 yards. There is no recoil in the Springfield, and a web belt is used, carrying 100 or more rounds. Twenty rounds have been fired with the new Springfield by experts in 15¾ seconds.

To-day the muzzle velocity per second of the different guns used by the various governments is as follows:

The United States Springfield, 2,300 feet per second.

French Lebel, 2,073.

English Lee-Metford, 2,000.

Spanish Mauser, 2,388.

Italian, 2,100.

German Mauser, 2,034.

The high power of the modern rifle has led to the invention of the cuirass or jacket and rifle shield, but they are no protection at fighting range.

Some of the great powers of Europe are looking for a still more deadly arm, and are experimenting with an automatic magazine rifle, or one in which the energy of recoil is used to reload the rifle.

The South African, Spanish-American and Chinese wars show that the wounds inflicted by the high-powered small-caliber bullets are of a merciful nature, producing but little shock, and, unless in a vital part, the wounds yield readily to treatment and recovery.

The manufacture of ammunition has increased almost sevenfold during the past two decades, with a corresponding increase in invested capital. The statistics of the industry are as follows:

Comparative Summary of Fire Arms Industry.

	1880	1890	1900
Number of establishments...	39	34	32
Capital invested............	$8,115,489	$4,672,424	$6,916,231
Wage-earners...............	4,862	2,660	4 482
Wages paid.................	$2,700,281	$1,575,931	$2 542,366
Value of Products..........	$5,736,936	$2,922,514	$5,444,659

Comparative Summary of Ammunition Manufacture.

	1880	1890	1900
Number of establishments...	4	35	33
Capital invested...........	$824,000	$4,368.529	$6,719,081
Wage-earners...............	1,066	2.158	5.231
Wages paid.................	$361,778	$969.951	$2,560 954
Value of products..........	$1,904,966	$6,538,959	$13,027,635

Hand-knit Goods.

Early Hand Knitting.—The art of hand knitting cannot be traced farther back than the year 1500. It was known in Scotland about that time. It consisted, as then practiced, in the construction of a looped fabric in which for the first row a succession of loops were cast on, or preferably knitted onto a needle and in succeeding rows, each loop was passed through the loop of each succeeding row. It differs distinctly from braiding, netting and weaving.

Crocheting.—Crocheting comes under the general heading of hand knitting, although it involves more care and special knowledge of the art. Much crocheting is done in the household, and the production in the aggregate forms quite an important percentage in the total knitted product. A great many handsome designs are used in the production of varieties of delicate goods in various shades and colors, and the art is being stimulated by the ready absorption of these fine products.

Displays of Hand Work.—Hand knitting, however, is declining steadily under the progressive improvements made in mechanical appliances for knitting, and, excepting as a household pastime, it is threatened with becoming a lost art. Splendid specimens of hand knitting, however, continue to be shown in exhibition of woman's deftness with fine yarns, and it is probable that there will always continue a limited, and it might be termed an æsthetic, demand for these exhibitions of feminine taste and skill.

Comparative Summary of Hand Knit Goods Industry.

	1880	1890	1900
Number of establishments...	39	28	86
Capital invested	$152,700	$78,468	$205,488
Wage-earners.......	1,814	186	304
Wages paid.................	$137,720	$35,852	$75,870
Value of products..........	$446,354	$205,775	$352,226

Harness and Harness Makers.

Use of Harness. — Harness, or what answered the purpose, has been in use from earliest times in connection with beasts of burden. In later times its manufacture has become greatly diversified in the large establishments where machinery is employed in numerous ways to prepare and use the material, which is chiefly leather.

Parts of Harness. — A mere enumeration of the parts of saddlery and harness manufacture shows the magnitude of the industry and the degree to which it has been diversified for economic and mechanical reasons. The parts of harness may be enumerated as follows: Traces, hames, choke-straps and billets, crupper, turnback, market tugs and billets, inside skirt, inside chape, outside skirt, outside billet, outside girth, reins, rein billets, hand parts, crown piece, crown layer, gag straps, throat straps, checks, winker brace, nose band, nose-band lining, check rounds, check billets, check centers, pads, fronts, bits, blinds, rosettes, post hooks, terrets, ring swivels, trace loops, ovals, monograms, roller buckles and harness buckles and rings, loop trace buckles, metal loops, twist-link breast chains and collar links and rings. All of these parts are usually to be found especially on Victoria harness. The variety of harness is adapted to the various vehicles to be drawn.

Harness Centers. — While there are very few well-defined harness centers, there are many cities where the industry is extensively conducted, such as New York, Newark, N. J.; Philadelphia, Cincinnati, Chicago, St. Louis and elsewhere. The manufacture of the metal parts has developed a number of large plants where all the numerous processes from pressing to plating are carried on.

Use of Chrome Leather.—One of the recent departures in the harness industry has been the use of chrome leather in a limited way. This leather is lighter and is not as much affected as the vegetable-tanned leathers by neglect, wet, atmosphere, heat or sweat of the horse. Chrome leather is more freely used in England for dray and van work, and is found to stand the strain better than ordinary tannages.

Harness Stock. — A problem now confronting the harness manufacturer is the buying of ready-cut harness stock. No matter how careful the cutting into the material is done in the harness shop, there is an average loss of three-eighths of a pound to a side. The effort is now being made to supply harness-makers with harness leather stock ready cut, in order that this loss in the shop may be reduced.

Saddlery Hardware. — Saddlery hardware is closely related to harness making, though a separate industry. The industry has assumed large proportions during the past decade, under the steady increase in demand for horse service.

Harness Mountings.—There is a strong tendency toward heavy metal mountings, especially metal terrets, hooks, trace and buck band buckles and rings, which are covered but not lined. A light mounting, celluloid-covered, is made up in white and russet. Three standard grades of light harness are now made. Aluminum bronze is now preferably used on solid metal, and close plate silver on white metal. All small buckles are leather covered. With single harness patent-leather folds are used on the breast collar, breeching and neck-strap bodies. Most owners prefer traces to buckle on the body, as the adjustment of the length of the traces can be made without the use of three or four dart-holes at the rear end.

The Saddle.—The latest saddle is made on a 3 or 3½-inch tree, the deep seat being preferred to the flat. In medium-grade harness some recent improvements are shown in the amount of stitching and quality of mountings. Traces, back straps and the body of the turnbacks are lined. Hame tugs are made with short safes; double harness has rubber-covered hames; terrets and draft-eyes are solid. Hooks, terrets and trace buckles aluminum bronze or silver-plated, and pads straight without ends. The sides are patent skirting with patent or plain leather trace-bearers. The turnbucks, except at the body, single strap; cruppers stitched on. Steel hooks are used at the bit ends of the reins, and are bent before the reins are made up.

Grades.—Of the three grades which manufacturers divide light harness into, the third grade meets with largest sale and is sold at low prices. This grade is cut of ordinary stock. In double harness of this grade, japanned of imitation rubber-covered electroplate draft eyes and terrets and half patent leather are used. The bridles are of the same style as the two higher grades, but flat-strapped, all-creased, split-leather winkers, pipe loops and plain leather fronts, with patent-leather top, harness-leather sides; trace-bearers, plain harness leather, hame tugs, sages under buckles only; box loops, traces stitched single row; stitching from ten to twelve to the inch; turnback, single; cruppers stitched on. Mountings are of brass, nickel, imitation or Davis hard rubber; small buckles and rings are of imitation rubber. Single harness in this grade has breast collar and breeching folds of plain harness leather, lap stitched one row; saddle, grade to suit; split skirtings, hip straps single; strap creased; turnback single strap, creased; crupper buckled on traces, wave stitched. Mountings are the same as on double harness.

Correct Appointments. — Correct harness and saddlery are more important than ever. No matter how well harness is made, it loses part of its value if it is not well trimmed and correct in form.

Comparative Summary of the Saddlery and Harness Industry.

	1880	1890	1900
Number of establishments...	7,999	7,931	12,934
Capital invested............	$16,508,019	$35,346,620	$43,354,136
Wage-earners..............	21,446	22,672	24,123
Wages paid................	$7,997,752	$10,908,918	$10,725,647
Value of products..........	$38,081,643	$52,970,801	$62,630,902

Comparative Summary of the Saddlery Hardware Industry.

	1880	1890	1900
Number of establishments...	64	102	80
Capital invested............	$1,655,550	$3,376,356	$3,335,356
Wage-earners	2,815	2,917	2,940
Wages paid................	$960,432	$1,260,325	$1,217,202
Value of products..........	$3,651,021	$4,118,195	$4,149,489

Hardware, The Making of.

Early Hardware Makers. — Hardware in its more primitive forms filled quite an important place in domestic economy. Ancient records mention a variety of uses to which iron was put by means of the anvil and hammer. The early blacksmith was the maker of most of the hardware in use, though the ancient wheelwright, carpenter and even stone mason frequently found themselves called upon to use their skill in the production of some device out of metal which would answer some domestic need. The hardware industry, as an industry, found its origin in the shop of the armor-maker, where implements of warfare were designed and carved. The requirements of early travel and transportation created demands which the early craftsman found it difficult to make with the crude instruments and crude materials at command.

Samples of Early Workmanship.—But the samples of workmanship which have come down to us entitle these early workmen to a high meed of praise for their ingenuity and excellent workmanship. As the early industries developed, the worker in hardware gradually found his craft assuming a distinctive feature. The workers in wood and the workers in leather called upon him for tools to prosecute their work; in fact, the first developments of all the industries were materially assisted by these ingenious workmen.

First Decided Start.—When the early forges were planted, the opportunity arose for the worker in metals to take his place among the craftsmen whose secrets led to the formation of guilds in the Middle Ages. Bands of iron to protect horses' feet are early spoken of, although for a long time they obtained extremely limited use, because of the difficulty of obtaining materials. The early forges, however, afforded these craftsmen wonderful assistance; they were called upon to furnish hinges for doors in place of leather, to furnish devices for locks to serve the purpose which keys subsequently filled. With the introduction of tools, a broad field opened before the hardware industry. While tools always existed, their use was limited, and almost all operations were performed by manual labor; but as tools increased in number, the work of the hardware craftsmen increased.

Separate Hardware Industry.—It is, however, to Americans that the hardware industry as a separate industry owes its importance. Considerable hardware was laboriously turned out in Germany and England for centuries, but it all lacked those characteristics which were subsequently developed by Yankee inventiveness. The establishment of the iron industry, and later the steel industry, opened up the wide field for hardware which it has since occupied. The multiplicity of uses to which it is applied is synonymous with industrial progress. Appliances and devices without number have been brought into use, which have practically laid, or helped to lay, the foundation of other important industries. Hardware is, in a sense, the connecting link between a host of industries without which it is difficult to conceive their existence. It made carpentry a craft, and it enters into the production of a vast variety of articles.

The Industry Specialized.—The industry as it exists to-day has been divided, subdivided and specialized until its widely divergent branches seem to have very little in common. It has developed a diversity of skill unknown in any other industry, and has facilitated the production of machinery and mechanical appliances upon a stupendous scale. Scores of industries owe their growth to the makers of hardware. The inventiveness and skill of these workmen are called into requisition in every step of mechanical progress. The industry is now diversified into over two hundred distinct branches, each producing its separate lines of work, with its separate methods and systems of work and rules. It uses iron, steel, glass, gold, copper, silver, wood, leather and many other materials to serve its ends, and it furnishes the connecting link, as it were, for uniting in a harmonious whole an industrial system which but for hardware would have made lamentably slow progress.

Tools and Utensils.—In utensils an industry has been built up involving the investment of millions of capital. Tools, a branch of the hardware industry, employ tens of thousands of workmen in hundreds of extensive establishments. Pins, which are diminutive hardware, constitute an industry alone, and it has reached large proportions. The railway system and all traveling facilities call upon the hardware industry for vast supplies. There is not an industry known but what depends upon the hardware manufacturer for devices which his skill has evolved.

Yankee Notions.—"Yankee notions" largely come under the classification of hardware, and Connecticut is entitled to the distinction of being their home. Of the 359 classifications assigned to manufactures, 249 are credited to this State. In one city patents were granted for the manufacture of bottle-top handles, wares for domestic convenience, shot-pouch chargers, lamp holders, bread toasters, scissors sharpeners, machines for sticking pins in paper (which helped Connecticut to undersell other markets), picture nails, carpet fasteners, clothes driers, necktie fasteners, eyelets, napkin holders, utensils for mixing liquids, perforated music sheets, washing machines, drawer pulls and church pew head-rests.

New Industries Established.—Tinware is an important branch of hardware. Its manufacture began in 1770. In 1795 Mark Leavenworth made axes, steelyards, ramrods and bayonets. Chauncey Jerome and Eli Terry began the manufacture of clocks about this time. Terry made his first clock in 1792, and Seth Thomas established the clock-making business on a firm foundation in 1808. In 1837 the clock industry was revolutionized by the use of brass wheels. Eli Whitney introduced the system of interchangeable parts of guns, and caused the failure of some of his competitors in consequence. Samuel Colt helped to broaden the hardware industry by his invention of the six-barreled revolver to be used with percussion caps. In 1835 he perfected his six-barreled rotating breech, which was used by Colonel Harvey for the first time in 1837, in fighting the Indians. Then came the Mexican War and the California gold craze. In 1858 Colt was turning out 60,000 revolvers a year. These weapons were used in the Crimean War and by Garibaldi in Italy. The making of the Spencer rifle and the Sharp rifle and the Winchester rifle greatly aided in building up the hardware industry.

Comparative Summary of the Hardware Industry.

	1880.	1890.	1900.
Number of establishments...	492	350	381
Capital invested............	$15,363,551	$26,271,840	$39,311,745
Wage-workers...............	16,801	18.495	26,463
Wages paid..................	$6,846,913	$8 656,067	$11,422,758
Value of products..........	$22,653,693	$26,726,463	$35,846,656

Hat and Cap Making and Materials.

Wool Hats.—The manufacture of wool hats, formerly an important industry, has fallen off steadily for twenty years by reason of the introduction of felt material. The decline during that time has been in the ratio of 8 to 3, as measured by the output. Where 32 workmen were employed in making wool hats in 1880, only 13 are employed now. It is a branch of the felt hat industry.

Fur Hats.—The material from which fur hats are made is the fur of the rabbit, coney and nutria. The finest fur comes from Germany, where it is cut from the skins. After the hairs are removed the skins are subjected to "carroting," which is an application of mercury and nitric acid, which holds the fibres together.

In 1846 the making of fur hats was carried on by hand. In 1835 Henry Blynn made a machine for stiffening hat bodies by immersing in certain solutions and then pressing them between rollers.

The First Process.—The first process in fur hat making is to mix the various kinds of fur in a machine called a "devil," in which the fibres are thoroughly pulled apart and mingled. Next a light current of air is blown through them which blows out all extraneous matter. The material is then fine and soft and so filmy that it hardly bears the touch.

Second Process.—This material is separated into boxes enough for one hat and this portion is placed in a revolving cone called a "former," which is pierced with small holes to admit air.

The fur is fed through a tube into a revolving cylinder which distributes it evenly; then jets of water are thrown on the embryo hat. This operation takes two or three minutes. It is then rolled and pressed, size being added to give it strength and durability.

Shaping.—The hat is next shaped, then blocked. Pouncing follows, which is a process of sandpapering, to remove inequalities, with emery paper.

Colonial Hat Making.—The colonists became such experts in hat making as long ago as 1731 that the felt-hat makers of London petitioned Parliament to prohibit the importation of hats from the colonies. Even the British Board of Trade became alarmed at the invasion of American hats into England, Spain, Portugal and the West Indies, and procured the passage of a law forbidding their exportation. Notwithstanding this the industry thrived all through the colonies. At a convention of hat manufacturers, held in 1831, it was stated that the annual production was $15,000,000 in value, and that 15,000 men and boys were engaged in the industry.

The Straw Hat.—The introduction of straw in hat making is more recent and the industry has grown to immense proportions, aided by ingenious mechanical appliances which vastly expedite manual processes and reduce the cost. The processes of preparation of material are simplified, and chemistry is brought to the assistance of the manufacturer to bring the material into proper condition for the rapid mechanical processes adopted. For centuries the manufacture of straw hats has been a special art in Tuscany and Signa. The manufacture of straw goods began in the United States in 1804, and the annual production of this country is about 30,000,000 hats.

Felt Goods Statistics.—There were, in 1900, 36 establishments in the United States manufacturing felt goods for hats with an invested capital of $7,125,276, employing 2,688 workers who earned $1,024,835, and who produced goods worth $6,861,691, including woolen and worsted material. The total quantity of felt produced was 2,056,002 square yards, representing a value of $548,545. Large quantities of felt are used in endless belts, as boot and shoe lining, hair belting and as trimming and lining felts, felt skirts, etc.

Statistics of Wool Hats.—There were 24 establishments engaged in the manufacture of wool hats, employing $2,058,802 capital, engaging 2,108 wage earners, to whom were paid $937,855, producing goods worth $3,591,940 in 1900.

The number of establishments engaged in fur hat making is 171; number of wage workers, 18,880; wages paid, $9,119,264; capital invested, $16,701,308; value of products, $27,811,187.

Home of the Panama.—Panama hats are made from the palmetto leaves. The plant is from six to fourteen feet high and the leaves four feet wide and over. It is found in various parts of Central and South America. Not all Panama hats are made in Panama; by far the greater number comes from Ecuador. The straw, previous to the plaiting, passes through several primitive preparatory processes. The best time for plaiting is usually in the morning and in the rainy season when the moist air is favorable to the best manipulation of the straw. When made in dry weather the hats show knots and breaks and other minor defects which much diminish their value.

Gathering of Material.—The leaves are gathered before they unfold; all their ribs and coarser veins are removed and the rest, without being separated from the base of the leaf, reduced to shreds. After having been placed in the sun for a day or so the straw is tied into a knot and then immersed in boiling water until it becomes white. It is then hung up in a shady place and subsequently bleached for two or three days, when it is ready for use.

Making the Hats.—Much of the straw is sent to Peru, where the Indians manufacture many products of great value from it. The plaiting of Panama hats is very troublesome, or at least tedious. The work commences at the crown and is finished at the brim. They are made on a block placed on the knees which requires to be constantly pressed with the breast. According to the quality of the work, more or less time is occupied in the completion of a hat. The coarser ones may be finished in two or three days, while the finest take as many months to make a single one, some consuming a year and over, it is stated. The Panama hat industry has within very recent years been injured by the production of imitation Panama hats which lack the valuable features and attractiveness and merit of the genuine Panama.

Comparative Summary of the Hat and Cap Industry.
(Not of Wool or Straw.)

	1880	1890	1900
Number of establishments...	489	705	816
Capital invested	$5,455,468	$13,724,002	$25,095,798
Wage-earners	17,240	25,931	31,425
Wages paid	$6,635,522	$12,650,917	$14,144,552
Value of products...........	$21,303,107	$37,311,107	$49,205,667

Hay and Straw Baling.

Appliances for Baling.—The modern devices and appliances for hay and straw baling present a number of ingenious and economic features for the rapid compression of these agricultural products for convenient shipment. Steam-power appliances are generally used for this purpose, although hand-power devices are not unknown. The cost of compression methods has been greatly reduced through the increase of mechanical capacity, and some of the appliances do as much work in one hour as was formerly accomplished in a week by more primitive methods. The compression is effected in such a manner as to not damage the marketable qualities of the products.

Heating and Ventilation.

History.—Of the modern methods of heating dwellings by fireplaces, stoves, furnaces, steam and hot-air apparatus, the fireplace is, of course, the oldest. Chimneys were not known before the twelfth century and the flues of the early fireplaces extended only a few feet up in the thickness of the wall.

The Franklin Stove.—In 1744 Benjamin Franklin invented a cast-iron open heater which projected out from the chimney and radiated heat into the room. The cast-iron box stove was invented in 1752. The first base burner was made in 1830. The first hot-air furnace was built in Worcester, Mass., in 1835. Heating by hot water was introduced into England in 1816, and was popular in Canada long before it was introduced into the United States.

Steam Heating.—Heating by steam originated in England, at Manchester, and was not introduced into the United States until a century later.

Hot-Water Methods.—Hot-water heating methods have this advantage over steam—that it furnishes heat very soon after the fire is started. There is no heat from steam until the water temperature has reached 212 degrees and none after it has fallen below that point. On the other hand, steam heat may be shut off more quickly than water. Steam boilers and hot-water heaters alike require a furnace with a grate surface for imparting the heat thus derived to the water in the heater or boiler.

Distribution Systems.—The system of distribution involves supply pipes for steam or hot water and return pipes for the hot water, in which special provision must be made for contraction and expansion. This system has been developed to scientific exactness as to details and immense structures are now most effectually and economically supplied with heat which is at all times under absolute and instant control.

Ventilation.—The science of ventilation has for its object the removal of foul air and the introduction of pure air into places occupied by persons. Ventilation is of two kinds—gravity ventilation and mechanical ventilation. Gravity ventilation is based on the fact that warmer air rises and is replaced by cooler air.

Mechanical ventilation depends on machinery for the movements of the air. It may be used to introduce fresh air or to expel foul air, or both. With either direct or indirect heating an air blast has the great advantage of perfect control of the fresh air supply. For the removal of foul air the mechanical method is better.

Mechanical Aids.—The more common mechanical aids are blowers or fans placed in air ducts, and either forcing the air ahead of them or creating a vacuum into which it rushes. The terms plenum or inflating, and vacuum or aspirating, are respectively applied to blowing in or sucking out the air. Engineers are not yet fully agreed as to the proper elevations for introducing fresh and removing foul air. Some authorities favor the location of the inlets and outlets on the same side of the room, the inlet to be above the heads of the occupants. The theory is that fresh air will ascend and pass along the ceiling and that the foul air will fall to the floor.

An objection to the location of inlets for either heating or ventilation is that the ascending air carries floor dust with it; another is that unless the inlets are very numerous the inrush of air will be unpleasant to those nearby.

Scientific Necessity For.—The extraordinary development of manufacturing, with its concomitant commercial expansion, has created a necessity for buildings of large size and great height, erected usually in congested localities, to be occupied by a great many persons engaged in industrial or commercial pursuits. The proper heating and ventilation of buildings of this character long ago became a subject of hygienic and scientific importance and personal comfort. While the fundamental principles underlying the distribution of heat and the introduction of pure air and the expulsion of impure air were well understood, the best and most practical means of economically applying these fundamental principles were for some time the subject of experimentation and frequently proved to be costly until experience and study pointed the way.

Kinds of Furnaces.—Furnaces may be divided into two general types, direct and indirect. Many direct-draft furnaces have no radiator. In the indirect-draft type the gases pass downward to a radiator, thence upward to the smoke-pipe. The old grate, which rotated around a center, is supplanted by the revolving triangular pattern. The fire-pots are generally made of cast iron or steel plate lined with fire-bricks 12 to 18 inches deep. The radiator built of cast iron or steel plate acts as a reservoir where the gases are kept in contact with the air passing over the furnace. The efficiency of a furnace chiefly depends on the area of the heating surface as compared with the grate. One pound of good anthracite coal should give off about 13,000 B. T. U. and a good furnace should utilize 70 per cent. of this heat.

Prior to 1871 the car stove was practically the only means of heating cars; the train-heating system of the present day is the outcome of a long number of patented inventions and trials and tests and experiments, which have resulted in a practically perfect system of heating.

The first water-heating system for trains, which utilized the heat of the steam taken from the locomotive, was introduced in 1894. An emergency heater under this system was placed in each car for the heating of water when steam heat from the locomotive was not available.

In the art of temperature regulation a very important improvement was introduced in 1900, which comprises in combination a circulatory heater, a thermostat in operative connection with some intermediate part of the heater. There is a passage which is controlled by the thermostat and there are means for cutting the thermostat out of action. By adjusting the thermostat along the heater the effective heating surface is varied.

A steam-heating system for towns was introduced as far back as 1877. It included a central steam generating plant with underground mains so constructed as to permit of expansion and contraction, surface pipes, steam meters and means for carrying away the water of condensation.

The Steam Boiler.—The usual sectional steam boiler is made up of slabs or sections, each one of which is connected by nipples with headers at the sides and top. The top header acts as a steam drum and the lower as mud drums, and also receive the water of condensation from the radiators. Tubular boilers are largely used for heating purposes, but are not adapted for dwellings. A boiler horse-power represents the evaporation of 34½ pounds of water at 212 degrees, which gives 33,317 B. T. U.

Power Rule.—One B. T. U. will raise the temperature of one cubic foot of air 55 degrees. The rule is, multiply the volume of air in cubic feet by the degrees raised and divide by 55. To raise 100,000 cubic feet of air 70 degrees.

$$\frac{100{,}000 \times 70}{55} = 127{,}272 + .$$

Radiators.—Cast-iron radiators give off an average per square foot of surface 1.5 B. T. U. The temperature of steam at 3 pounds pressure is 220 degrees; subtracting 70 degrees, the normal temperature, we have 150 degrees, the average difference between the temperature of steam and the air of the room. Therefore we have 150 × 1.5 = 225 B. T. U. as the efficiency of the average cast-iron radiator. A circulation coil would give off 300 B. T. U. The three systems of piping are known as "two-pipe," "one-pipe" and "one-pipe circuit system." The radiators are freed from air when steam is turned on, by various forms of air valves. A very vital matter is the proportioning of the size of steam-pipes. There are several methods employed in the adjustment of steam piping to the requirements of the building to be equipped, all based on experience and close observation.

Types of Radiators.—The types of radiators for indirect heating come in quite a variety. The efficiency of an indirect heater depends upon its form, difference of temperature between the steam and the surrounding air and the velocity with which the air passes over the surrounding air. The principles are the same as in direct heating. To compute heating surface required to warm and ventilate a building, take, for example, a school-room, zero weather, where the heat loss of conduction through walls and windows is 36,000 B. T. U. and the supply of air is 100,000 feet per hour. By first rule given we had

$$\frac{100{,}000 \times 70}{55} = 127\ 272 \text{ B. T. U. required for}$$

ventilation. Now 36,000 + 127,272 = 163,272 B. T. U., the total heat required. Divide this by 600, the ascertained efficiency of the indirect radiators in this case, and we have 272 square feet of surface required. There are simple rules for determining the size of warm-air flues and cold air direct. The "two-pipe" system is used in indirect heating. The rules for the care and management of steam-heating boilers are well defined and are to be found in many works devoted to the elucidation of this interesting subject.

Hot-Water Heaters.—Hot-water heaters differ from steam boilers, particularly in not having the reservoir or space for steam above the heating surface. Automatic regulators are often used to maintain a constant temperature of the water, of which there are many varieties in common use.

Mechanism of Hot-Water Heaters.—In the direct hot-water heating system the hot water flows through the pipes, giving up its heat by conduction to the coils and radiators, which in turn transfer it to the air of the room. Hot-water radiators differ from steam radiators in having a horizontal passage at the top as well as at the bottom to draw off the air, which gathers at the top of each loop or section. The efficiency of the hot-water radiator is determined this way. Assuming 170 as the average temperature, subtracting 70, we have 100, multiply by $1.5 = 150$, efficiency.

Piping of Hot Water.—In piping hot water the mains and branches have an upward inclination; the returns are parallel to the mains and are inclined downward. The expansion tank is placed above the highest radiator. The capacity of this tank in gallons is determined by dividing the square feet of radiation by 40.

The Combination System.—The combination system secures the advantage of a hot-water system for moderate temperature and of steam heating for extremely cold weather. The size of pipe depends on four conditions, size of radiator, elevation above boiler, length of pipe and difference in temperature between supply and return.

Pipe Proportions.—Indirect hot-water heaters are used principally in the warming of dwelling-houses, but it is not desirable to supply more than 80 to 100 square feet of radiation from a single connection. The sizes of pipes for runs up to 100 feet range, as follows: 1 inch, 15 square feet indirect radiation; 1¼, 30 square feet; 1½, 50 square feet; 2, 100 square feet; 3, 300 square feet; 3½, 400 square feet; 4, 600 square feet; 5, 1,000 square feet.

Exhaust-steam heating calls for a system of piping that allows only a slight increase of back pressure to be thrown upon the engine. In the low-pressure or vacuum systems the pressure in the heating system is less than the atmosphere.

Systems of Circulation. — The circulation through the radiators is produced by suction rather than by pressure, which has several advantages. The Webster system has an automatic outlet valve on each coil and radiator connected with some form of suction apparatus. In the Paul system the suction is connected with the air valves instead of the returns, and the vacuum is produced by means of a steam injector instead of a pump. The returns are carried back to the receiving tank and pumped back to the boiler.

Forced-Blast System.—The forced-blast system has an advantage over the gravity system. The exhaust method consists in draining the air out of a building and providing for the heat thus carried away by placing steam coils under the windows or elsewhere.

The Plenum Method.—In the plenum method the air is forced into the building and quality, temperature and point of admission are completely under control. All spaces are filled with air under slight pressure and the leakage is outward, and ample opportunity is afforded for warming the air by means of heaters.

Rules for Efficiency.—The rule for determining efficiency of a heater with forced blast is shown in this example: If 600,000 cubic feet of air per hour is to be raised from 10 below zero to 80 above, with a velocity through the heater of 800 feet per minute and a steam pressure of 5 pounds, we have

$$\frac{600{,}000 \times 90}{55} = 981{,}818 \text{ B. T. U.}$$

In this case a heater 10 pipes deep is required giving an efficiency of 1,500 B. T. U. Hence $\frac{981{,}818}{1{,}500} = 654$ feet of surface. In making this and all other similar calculations it is necessary to consult tables, especially prepared, to know what divisor to use for a given pressure. In this particular case the divisor is 55 and 90 is the addition of 10 degrees below to 80 degrees above.

Example.—Take an audience hall calling for 400,000 cubic feet of air per hour; loss of heat through walls in zero weather 250,000 B. T. U. What should be the size of the heater and how many rows of pipe deep with 20 pounds' steam pressure?

$$\frac{400{,}000 \times 70}{55} = 509{,}090 \text{ B. T. U. for}$$

ventilation, adding 250,000 to 509,090, we have

759,090 B. T. U. to be supplied. In this example 70 represents normal temperature.

Rules for Regulating Fans.—Relative to fans the following rules are established:

1. The volume or air varies directly as the speed of the fan, *i. e.*, doubling the number of revolutions doubles the volume of air delivered.

2. The pressure varies as the square of the speed; for example, if the speed is doubled the pressure is increased, $2 \times 2 = 4$ times.

3. The power required to run the fan varies as the cube of the speed; if the speed is doubled the power required is increased $2 \times 2 \times 2 = 8$ times. Electric motors are especially adapted to fans. With the blower type of fan the size of the main ducts may be based on a velocity of 1,200 to 1,500 feet per minute; the branches on a velocity of 1,000 to 1,200 feet, or when the pipes are small, as low as 600 to 800 feet. Flue velocities of 500 to 700 feet may be used. Factory practice allows 100 to 150 cubic feet of space per foot of pipe. Take a machine shop 100 feet long, 50 feet wide, 3 stories, each 10 feet high, to be warmed by forced blast, using exhaust steam in the heater, air to be returned to the heater and to pass through it every 15 minutes. What size of blower will be required? The total volume of air is $100 \times 50 \times 3 \times 10 = 150{,}000$ cubic feet.

$$\frac{150{,}000}{140} = 1{,}071 \text{ feet of pipe.}$$

In this problem the divisor 140 is found in the tables of calculations covering all conditions and which must be consulted and followed in all estimates.

Double Direct System.—The double direct system permits more heat to be supplied to certain rooms in a building than others. The temperature in given rooms is regulated by mixing with the hot air a sufficient volume of cold air at the bases of the different flues.

The Disk Wheel.—The disk or propeller type of wheel is used where air is to be moved against a very light resistance. A form of light construction is adopted which is connected with the main vent flues.

Electric Heaters.—Electric heaters have a wide range of application, are instantly available and are regulated at will. The commercial unit for electricity is one watt for one hour and is equal to 3.41 B. T. U. Electricity is usually sold on the basis of 1,000 watt hours called kilowatt hours, which is equal to 3,140 B. T. U. A watt is the product of a current of one ampere by an electromotive force of 1 volt.

Heat is obtained from the electric current by placing a greater or less resistance in its path. The method of wiring for this purpose is essentially the same as for lights.

The temperature regulators have three essential features, an air compressor and reservoir and distributing pipes; second, thermostats; third, diaphragms or pneumatic valves at the radiators.

Heating of Office Buildings.—In heating and ventilating heaters, air is forced into closed spaces beneath the auditorium and balcony floors and discharged upward through small openings. Office buildings are satisfactorily warmed by direct steam, hot water, or where ventilation is desired, by the fan system.

Apartment Houses. — Apartment houses are warmed by furnaces, direct steam or hot water. The systems of heating and ventilation are the result of long, patient and scientific study and experiment by a class of engineers who deserve much from the public for their achievements.

Rules of Computation.—The required grate surface of the heater may be computed by knowing the number of gallons to be heated per hour and the rise in temperature required, as follows: Reduce the gallons to pounds by multiplying by 8.3 and this result multiply by the rise in temperature to obtain results in thermal units. Assuming a combustion of 5 pounds of coal per square foot of grate and an efficiency of 8,000 thermal units per pounds of coal, we have—grate surface in square feet =

$$\frac{\text{gals. per hour} \times 8.3 \times \text{rise in temp.}}{5 \times 8{,}000.}$$

Problem.—How many square feet of grate surface will be required to raise the temperature of 200 gallons of water per hour from 40 degrees to 180 degrees?

Using above formula, we have:

$$\frac{200 \times 8.3 \times (180\text{-}40)}{5 \times 8{,}000.} = 5.8 \text{ square feet.}$$

Application.—Take a hotel with 30 bath-tubs, which are to be supplied three times each between hours of 7 and 9 o'clock, 20 gallons for bath, with 400 gallons storage tank. Starting with tank full of hot water, how many square feet of grate surface will be required to heat the additional quantity of water within the stated time, if its temperature is raised from 50 to 130 degrees?

If steam at 10 pounds pressure is used instead of a heater, how much heating coil will be needed?

Gallons of water required — 30 × 3 × 20 = 1,800. Subtracting 400 gallons already heated, we have 1,400 gallons to be heated. Rise in temperature, 130 — 50 = 80 degrees.

B. T. U. per hour = 700 × 8.3 × 80 = 4,648,000, which divided by 5 × 8,000, gives 11.6 square feet of grate.

Practical Problem.—To ascertain square feet of coil surface. Temperature of steam at 10 pounds = 239 degrees. Average temperature of water in the coils, 90 degrees = 239 — 90 equals 149 degrees, the difference between steam and average water temperature. B. T. U. square feet of heating coil per hour equals 149 × 200 = 29,800. Dividing 4,648,000 B. T. U. per hour by 29,800, we have 15.5 square feet of coil surface.

The solution of all such problems is effected by reference to the voluminous tables published in connection with the plumbing craft. These tables were early used and enable the mechanic to solve all ordinary and even complex problems.

Horseshoes, The Making of.

Growth of the Manufacture.—The manufacture of horseshoes became a separate industry some fifty or more years ago, soon after the manufacture of iron on a large scale. Prior thereto horseshoes were—and still are, in many remote quarters of the globe—laboriously hammered out. The earlier efforts at horseshoe making were crude, but the inventive talent of workers in iron soon devised machinery which enormously increased the production and materially decreased the cost. The machinery is complicated but highly practical, and turns out shoes unerringly exact.

Material Used.—The material used is of special manufacture, and has been brought up by proper manipulation to meet the demands. The use of shoes is so universal that the consequences of their absence is never thought of. The value of the factory output per year is at present in excess of $1,000,000. To this amount must, of course, be added a much larger sum for the value of horseshoes made outside of regular factories.

Among the many varieties of horseshoes made are light, medium and heavy shoes in iron or steel, long-heel shoes in heavy, light and medium weights; short-heel, extra light, extra swaged, city pattern, long-heel city pattern, light driving, snow shoes, broncho shoes and mule iron and steel shoes. The industry supplies 16,000,000 horses.

Horse Clothing Industry.

Rise of the Industry.—Until within comparatively recent years the providing of horses with clothing of any kind attracted comparatively little attention. As they were unable to make known their wants or to express their opinions of their owners, on cold days they were permitted to go unprotected and unprovided for until a humanitarian sentiment took the place of former indifference. The breeding of race horses, carriage horses and horses for general driving and riding was the first actual stimulus to the manufacture of clothing for horses; as soon as it became the fashion to have some regard for the comfort of horses, factories began to turn out all varieties of horse clothing. No well-equipped stable is now complete without covering for each horse, and even provision is made for the ordinary work horses by which they will be protected from extreme cold, and in the extreme heat of summer with horse bonnets.

Horses at liberty can bear a great deal of cold safely. So exposed, they become rough as bears and sluggish as donkeys. In many well-conducted stables horses are provided in winter with summer clothing of light kersey, with a quarter-cloth of brown Holland, neatly bound with colored tape, often adorned with a crest or monogram, which cost from $5 to $10 each.

For ordinary use there should be a day suit and a night suit. The day suit may consist of a common rug, cut out to fit and fastened over the chest. One or two additional blankets might be provided for very cold weather. Well-fitting sets of knee-caps should be kept on hand in every stable and always put on the horses when sent out to exercise. Hoods are good when long journeys are to be made by rail in cold weather. Horse clothing made of blankets instead of the usual felted cloth is best for night clothing, because in lying down it is sure to get dirty. It is false economy to use the same horse clothing day and night.

Grooms should be made to understand that although draughts are injurious, horses will be poisoned in a hothouse-like stable, and may be kept in capital condition in the coldest dry stable if they are warmly clothed. The average temperature should be between 45 degrees and 50 degrees Fahr., or a little warmer in winter than the outside air. If it smells hot, it is too hot. A registering thermometer hung up in a stable of valuable horses will be a useful silent witness for the horse owner.

There should always be a supply of bandages. Clothing assists in giving the horse a good smooth coat and for protecting horses from chill.

Production of Horse Clothing.—In 1900 there were made 514,952 square yards of horse blankets, all wool, worth $256,211; 1,094,537 square yards cotton mixed, worth $228,943, and 5,702,315 square yards woven on cotton warps with weft partly or wholly of wool, worsted or hair, worth $1,252,824, a total of 7,711,804 square yards, which shows that the horses are pretty well looked after, but they deserve still greater regard.

Comparative Summary of the Horse Clothing Industry.

	1880	1890	1900
Number of establishments..	3	31	26
Capital invested	$410,000	$1,028,528	$653,545
Wage-workers	565	881	575
Wages paid	$137 400	$239,074	$176,687
Value of products..........	$695,000	$1,572,265	$1,305,164

Hosiery and Knit Goods.

Colonial Manufacturers.—The manufacture of hosiery was introduced into the colonies by the German Palatines, who settled in a suburb of Philadelphia, Pa., known as Germantown. William Penn established the holding of semi-annual fairs, and at these fairs the hosiery made by the Germans constituted a striking exhibit. The industry has thriven ever since and is now one of the most important in that city. Many of the most famous and successful knitting machines have been invented and built there. Knitting early became a house occupation, but in later years became centralized in vast plants.

First Stocking Factory.—As late as 1831 the only stocking factory in the United States was at Newburyport, Mass., though there are records of patents having been previously granted for knitting machines. In 1837 knit hose and knit shirts were made in a factory at Lowell, Mass. In 1850 there were only three knitting mills in the State of New York.

Automatic Appliances.—In the art of knitting, inventions of the most important character and of valuable peculiarities have been introduced during the past twenty-five years. These improvements have been in the direction of producing automatic power machines to do all the work that human fingers could possibly do in the production of machines capable of turning out complete articles.

Circular Machines.—Circular machines were devised as long ago as 1859, but they were very crude and did not obtain recognition. The first practical machine of this character was the Shaw, brought into use in 1879, in which the desired automatic operation was secured. It provided means by which, at proper points, a splicing or reenforcing thread could be introduced and removed. This machine stimulated inventive enterprise, and a long series of important steps began to be taken which has brought up the knitting machine to its present phenomenal efficiency.

Many fabrics of new kinds, which were formerly made by hand, are now made on reciprocating machines, familiar in many respects to the early stocking loom. These goods are now largely made on rotating automatic machines. Machines have been generally introduced for the manufacture of seamless hosiery which exhibit a remarkable triumph in mechanism. The prevailing fashions have caused great activity in the invention of machines for knitting open work hosiery, and among these improvements may be mentioned those of Steber, Houseman, Brown, Ellis and Blood.

The Lamb and Cotton types exhibit the highest improvements of the flat bed or straight knitting machines. Remarkable advances have been made in machines for the knitting of ribbed and striped fabrics. Along this line 1,986 patents have been issued.

History of Progress.—In 1850 there were only 85 hosiery mills in the United States, producing about one million dollars' worth of goods. In 1900 there were 921, producing over ninety-five million dollars' worth of products. The number of wage earners fifty years ago was 2,325. In 1900, 83,387. Few industries on the American continent have grown so rapidly or are so firmly established. It offers opportunities for young persons to earn good wages with moderate exertion.

Power Knitting Machines.—A great event was the introduction of the power knitting machine. This revolutionized the industry and greatly reduced cost of manufacture and resulted in the establishment of a vast industry. Hand knitting frames very early supplanted the old-time manual methods. These frames, while simple in construction, added much to the factory capacity and, in fact, made factory operations possible. Away back in 1810, over 100,000 pairs of stockings were manufactured in Pennsylvania, and in

HOSIERY & KNIT GOODS IN UNITED STATES | HATS & CAPS IN THE UNITED STATES

FROM CENSUS REPORTS

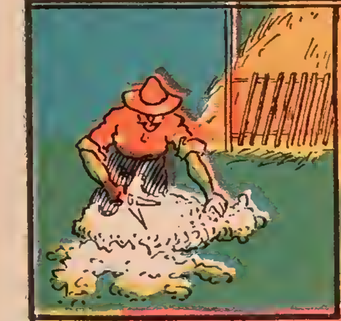
These figures are for the manufacture as a factory product.

	1900	1890
No. of Establishments	1,007	824
Capital	$82,066,092	$50,686,206
Salaried Officials	2,831	1,659
Salaries Paid	$3,138,160	$1,711,291
Wage Earners	83,691	59,774
Wages Paid	$24,434,497	$16,613,970
Miscellaneous Expenses	$6,627,724	$3,647,597
Cost of Materials	$51,195,868	$35,949,865
Value of Products	$95,834,792	$67,446,788

These figures are for manufactures as factory products, and they include fur hats and wool hats

	1900	1890
No. of Establishments	840	737
Capital	$27,146,600	$17,866,226
Salaried Officials	1426	1,354
Salaries Paid	$1,685,557	$1,557,798
Wage Earners	33,533	29,431
Wages Paid	$15,082,407	$13,900,893
Miscellaneous Expenses	$2,625,887	$1,900,836
Cost of Materials	$26,463,254	$18,962,843
Value of Product.	$52,797,697	$42,641,520

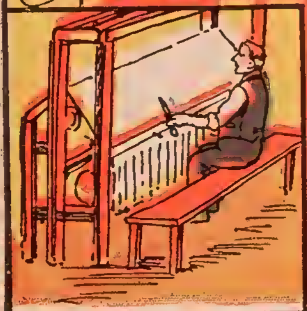
WOOL CROP OF U.S. BY STATES.

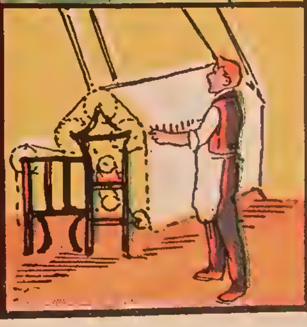


REPORT OF CENSUS BUREAU.

	POUNDS	VALUE DOLLARS		POUNDS	VALUE DOLLARS
ALABAMA	744,274	150,943	MISSISSIPPI	779,310	144,758
ALASKA	----	------	MONTANA	30,437,829	5,136,658
ARIZONA	3,352,937	426,318	NEBRASKA	2,788,839	426,344
ARKANSAS	636,974	118,922	NEVADA	4,842,500	692,403
CALIFORNIA	13,680,495	1,707,088	NEW HAMPSHIRE	409,645	84,103
COLORADO	8,543,937	1,115,331	NEW JERSEY	146,628	31,266
CONNECTICUT	104,438	22,534	NEW MEXICO	15,209,199	1,954,171
DELAWARE	32,350	6,618	NEW YORK	6,674,165	1,387,969
DIST. OF COLUMBIA	-----	-----	N. CAROLINA	797,176	150,510
FLORIDA	333,898	66,881	N. DAKOTA	3,030,478	503,744
GEORGIA	777,189	155,811	OHIO	20,350,721	4,299,025
HAWAII	424,228	53,686	OKLAHOMA	278,425	37,750
IDAHO	15,474,447	2,210,790	OREGON	18,349,660	2,396,741
ILLINOIS	4,799,742	966,746	PENNSYLVANIA	6,732,226	1,381,689
INDIANA	6,891,601	1,491,743	RHODE ISLAND	35,180	8,741
INDIAN TER.	50,711	7,490	S. CAROLINA	175,290	31,537
IOWA	5,015,965	992,334	S. DAKOTA	3,246,945	525,652
KANSAS	1,599,374	247,895	TENNESSEE	1,395,295	263,351
KENTUCKY	3,617,497	737,632	TEXAS	9,638,002	1,428,122
LOUISANA	547,691	90,317	UTAH	17,050,977	2,599,638
MAINE	1,487,018	318,585	VERMONT	1,334,253	268,967
MARYLAND	632,119	142,966	VIRGINIA	2,020,735	409,602
MASSACHUSETTS	195,876	40,291	WASHINGTON	5,268,088	618,975
MICHIGAN	12,202,844	2,454,399	W. VIRGINIA	3,123,455	636,012
MINNESOTA	2,612,737	460,305	WISCONSIN	7,224,733	1,461,279
MISSOURI	4,145,137	822,871	WYOMING.	27,758,309	4,036,227

TOTAL CROP FOR U.S. 276,991,812 POUNDS VALUE $45,723,739.





1858, 700 hand-knitting frames were in operation in the city of Philadelphia alone, which has become a great hosiery center. Inventive talent has never ceased to develop improvements in knitting machines and the facility with which they execute work is a matter of wonderment to all unfamiliar with the remarkable progress which has been made. A description of a modern knitting machine, while interesting to an experienced knitter, would involve a mass of technical details of no special interest to others. These superb specimens of mechanical skill act automatically, satisfied with a supply of yarn and a minimum of attention.

The Industry in the South.—The growth of the industry, especially throughout the Southern States during the past decade, has been marvelous and has been due to the abundant supply of yarns at home and to the availability of comparatively unskilled labor. These machines, to an uninitiated observer, appear to do all the work, it being difficult at first to perceive what particular relation the attendant has to do with the product. Tiny metallic fingers seize at the right instant and in the right way the raw material, and in its successive steps to sock-hood and stocking-hood it finds its progress provided for by the delicate mechanism to the final result. These machines have routed hand labor and the later ones have driven the earlier ones to the scrap pile. The cost of manufacture has been amazingly reduced.

Output Per Worker Increased.—Another feature is worth mentioning, viz., with the improved machinery the output per worker increased during the half century over double and at the same time the wages per wage worker have more than doubled. Pennsylvania naturally leads in this industry; New York comes second. There were in 1900, 521,871 spindles, of which 290,366 were woolen, 14,064 worsted; 205,742 cotton spinning, and 133 looms, in addition to 89,047 knitting machines of all kinds, 24,535 sewing machines and 161 sets of woolen cards.

Increase in Power and Capacity.—Knitting machines are increasing in power and capacity. Large circular machines are now made, which are operated by power and are capable of an immense production, which makes it difficult for plants of smaller sized machines to exist.

Spread of the Industry.—The industry continues to extend to the southward and westward. States west of the Mississippi have 129 factories. Women and children are largely employed. In 1860 there were only three hosiery factories in the South. In 1900, 71 were reported, which number has since been increased considerably. The use of knitted cotton garments has increased very rapidly, and includes underwear, hoods, scarfs, nubias, cardigan jackets, knit shawls, fancy goods, boot and shoe linings and some jersey cloth.

Machinery Capacity in Hosiery and Knit Goods Production.

	1880	1890	1900
Cards	592	1,183	1,161
Combing machines	3	16	15
Knitting machines	12,659	36 327	89,047
Sewing machines	4,659	......	24,535
Looms	1,964	149	133
Spindles	143,023	389,353	521,871

Varieties of Goods.—Among the kinds of goods produced are flat-ribbed goods, plain flat, full fashioned flat, ribbed; full fashioned flat, plain; circular ribbed, circular plain and circular hosiery; hose and half hose of wool, cotton or silk; stockings of like materials; shirts and drawers; combination suits; leggins and garters; gloves and mittens; hoods; scarfs; nubias; cardigan jackets; sweaters; athletic goods; fancy jackets; shawls; wristers and fancy knit goods; boot and shoe linings; astrakhans and jersey cloth and stockinette.

Materials.—All these various lines of goods are produced on specially devised and adapted machines, in which the fundamental principle is the same. Among the materials worked up to produce the various kinds of goods called for are wool, foreign and domestic; cotton, shoddy, wool waste, camel's hair and mohair. The yarns used are woolen and worsted, merino, cotton, silk, linen, jute and ramee.

A Comparative Summary of the Hosiery and Knit Goods Industry in the United States.

	1880	1890	1900
Number of establishments	359	796	921
Capital invested	$15,579,591	$50,607,738	$81,860,604
Wage-earners	28,885	59,588	83,387
Wages paid	$6,701.475	$16,578,119	$24,358,627
Value of products	$29,167,227	$67,241,013	$95,482,566

House Furnishing Goods Industry.

A Growing Industry.—The providing of house-furnishing goods has within a few years developed a number of minor and specialized industries, in each of which some one or more particular lines of goods are produced.

Furnishing Stores.—The rapid multiplication of small houses during the past few decades, each furnished practically in a similar manner and with practically similar material, articles and utensils, created a market for large supplies which led to special efforts of merchants to meet these requirements. Hence house-furnishing stores have grown in number and extent wherein almost any article desired for kitchen, pantry or dining-room can be had. These stores represent the changing habits and methods among the people, and they are also indicative of the growth of commercial instincts peculiar to our own age for the supply of these wants.

Necessity of House Furnishings.—The rapid building up of cities and towns calls for the quick equipment of homes. The habits of the people, the frequent changes of homes, due to suddenly developed opportunities for employment, create necessities for immediate furnishings which could not be supplied under older business methods. The house-furnishing store represents an advance in business methods and an adaptability to the new conditions and requirements of the day. The business of these stores has increased over tenfold within twenty years. It is a matter of great convenience for householders to find under one roof almost any article of domestic convenience attractively displayed.

Comparative Summary of Housefurnishing Goods not Otherwise Mentioned in the Census.

	1880	1890	1900
Number of establishments ...	48	133	210
Capital invested	$456,806	$6,939,659	$10,638,248
Wage-earners................	592	3,417	5,212
Wages paid..................	$216,890	$1,506,929	$1,837,552
Value of product	$1,332,188	$8,347,285	$14,280,575

Ice Making.

Refrigeration Processes.—The statement might at first sight appear incredible, but it is verified by the records of the United States Patent Office that 4,337 patents have been granted for various processes of refrigeration. The first machine for the manufacture of ice was invented in 1755, and was based on the principle that the creation of a vacuum increases the evaporation of water, and by this means produces ice. In 1810 the chemical affinity of sulphuric acid for water was discovered and ice was produced by this agency.

The First Ice Machine.—The first commercially successful ice-making machine was made by Jacob Perkins, an American engineer residing in London, who obtained a patent for his machine in 1834. The refrigerant was ether, and the evaporator containing it was inclosed in pipes through which the brine circulated at a temperature of 5 degrees Fahr. In 1850 Professor Twining, of New Haven, patented an ice machine in England, and in 1855 produced a machine in Cleveland, Ohio, which made 1,600 pounds of ice in twenty-four hours. Professor Twining discovered that ice frozen at a temperature slightly below the freezing point would be transparent with the exception of the small porous core, while if frozen at a lower temperature it would be opaque and porous throughout. The machine which indicated the modern ammonia absorption system, was made by a Frenchman in 1860; it was by this machine that the trade in frozen meat was introduced to the world. Captain David Smith, of Chatham, Mass., originated the plate-ice system, and erected the first machine of this kind in Oakland, Cal.

Historical References.—The ancients understood the art of producing cold by artificial means. It was early discovered that porous receptacles would keep their contents cooler than non-porous, and in Egypt and East India vessels containing water to be frozen were covered with stalks of corn or sugar cane. In some localities in the Far East as many as 100,000 pans were used in making ice in extremely porous pans. The Egyptians allowed jars of boiled water to remain on the house roofs over night, and in the morning they were moistened with water on the outside and bound with grass or plants and put in trenches.

Cool Drinks.—Mediæval history tells of the custom of cooling drinks, which spread from Greece and Italy to France and Western Europe. Saltpetre was first used by the Italians about 1550 for refrigerating purposes. The liquid to be cooled was put in a little-neck bottle, which was immersed in a receptacle filled with cold water; saltpetre was then added to the water of the outer vessel, and the bottle containing the water or liquid to be cooled was twirled around on its axis, the proportion of saltpetre to water being 1 to 4 or 5.

Natural Ice.—Natural ice as an article of commerce did not obtain importance until the beginning of the nineteenth century. The year 1805 may be regarded as the beginning of the industry in the United States. Cargoes of ice were shipped to the West Indies, and later on to South Atlantic and Gulf ports.

Two Systems.—There are two systems in manufacturing ice, known as the "compressor" and the "absorption" systems. The compressor system, which is by far the more important of the two, involves three successive steps, respectively called compression, condensation and expansion. Ammonia, which contains no water in the gaseous form, is subjected to a pressure of from 125 to 175 pounds per square inch, by the use of a pump employing steam or other power. The gas is then reduced to a liquid state by condensation, by passing the ammonia through coils of pipe which are in contact with cold water or some other cooling medium. The excess of heat is then given up and the ammonia reduced to the liquid state. It then expands, or becomes gaseous, in the coils of the pipe which are in contact with the water to be frozen. This reduces the temperature of the ammonia gas below the freezing point of water, and the ammonia absorbs from the water to be cooled, the heat which was taken from the former during condensation. This of necessity results in the freezing of the water, which is the theory of all refrigerating processes. The ammonia, having done its cooling work, returns to the compressor and is used over again.

The Absorption Process.—An aqueous solution of ammonia is used, in which four successive steps are involved, namely—generation of gas, condensation, expansion and absorption. Heat applied to the aqua ammonia converts it into a gas, raises the pressure between 120 pounds to 160 pounds per square inch. The ammonia is then condensed by being conducted through pipes in contact with cold water. Expansion then follows. The ammonia is changed from a liquid to a gas, and being greatly reduced in temperature, absorbs heat from the pipes, thus producing ice.

Materials Used.—Ammonia—anhydrous and aqua—is the principal material used as a refrigerant. The principal item of expense is the cost of the fuel used to operate the machinery. The other materials used include brine, made either with sodium chloride—which is common salt—or chloride of calcium, ammonia, ammonia anhydrous and ammonia aqua.

Can System.—Practically all the ice manufactured in the United States is produced by the can system or plate system. In the can system distilled water is used, which is furnished by condensing exhaust steam from the refrigerating machine or by condensing live steam. It is formed either in stationary cells or in removable cans. In removable cans, the cans full of water are immersed in iron or wooden tanks containing cold brine, and can be taken out singly and replaced by others. The ice is removed by dropping the can into or sprinkling it with tepid water, the time required for forming ice varying from twenty to sixty-six hours, according to the thickness of the mold and the temperature of the brine. A 50-pound block, with brine at 18 degrees, can be made in 20 hours, 100 pounds in 36 hours, 200 to 300 pounds in 60 hours, and 400 pounds in 60 hours.

Plate System.—In the plate system a hollow iron plate is immersed in a tank containing the water to be frozen. The ice forms on the two outer surfaces. Production of ice is slower by this process, and for this reason several plates are necessary for a continuous process. The ice cake may be of several sizes, the standard being 16 feet long, 8 feet wide and 11 inches thick. Electric power is generally used.

The production of ice in 1900 was 4,294,439 tons. The chemical materials used are ammonia, ammonia anhydrous and ammonia aqua.

Comparative Summary of the Ice Manufacturing Industry.

	1880	1890	1900
Number of establishments..	35	222	775
Capital invested	$1,251,200	$9,846,468	$38,019,507
Wage-earners	447	2,826	6,880
Wages paid..................	$140,885	$1,095,996	$3,402,745
Value of products...........	$544,763	$4,900,983	$13,780,978

India Rubber and Its Uses.

History.—While comparatively a minor industrial product, India rubber within the past few years has reached a position of importance in the industrial world which entitles it to considerable attention. The first notice of India rubber on record was due to Herrera, who in the second voyage of Columbus observed that the inhabitants of Hayti played a game with a ball made of the gum of a tree. Torquemada, in 1615, mentioned the name of the tree producing it. The Spaniards learned to use the juice of the tree to waterproof their cloaks. It was La Condamine, who was sent on a scientific expedition by the French Government to Quito in 1735, who first gives us any intelligent account of it. It was not, however, until about 1830 that the production of rubber assumed commercial importance. In that year 464 hundredweights were imported in England, which increased to 6,640 hundredweights in 1840, and

152,118 hundredweights in 1870. Since then its production and consumption have enormously increased, and plantations are now being established for the growth of the caoutchouc-yielding tree.

Best Rubbers.—The rubbers most highly prized for their resisting and enduring qualities are Para, Ceara and Madagascar rubbers. The greatest readily accessible territory is in South America, where the gathering of caoutchouc has become the chief industry of a large portion of the population in the rubber belt. Para rubber is chiefly obtained from a large euphorbiaceous tree, upward of sixty feet in height. It grows abundantly in the moist, steamy valleys of the Amazon and its tributaries. The caoutchouc is gathered between August and February. The trees are tapped in the evening, and the juice is collected the following morning in small shallow cups made from clayey soil dried in the sun, and which are placed below the incisions to receive the milk. Each tree averages six ounces of juice in three days, and it boils down, yielding about one-third its weight in rubber. The milk is carefully dried in the vapor of oily palm nuts, and as it hardens is placed in layers one on the other. All West Indian countries, including Mexico, produce rubber, differing in quality and value. Considerable supplies are received from Africa and Asia.

Its Composition.—Its average ultimate composition is 87.5 per cent. carbon and 12.5 per cent. hydrogen, which chemists express by C_1OH_8; at 0° C. it becomes rigid, and is restored at 35° to 40° C. Caoutchouc at 120° C. becomes soft, at 150° C. viscous, and at 200° C. melts. Concentrated nitric acid destroys it. It is porous and cellular, and when long soaked absorbs 10 to 25 per cent. water. For commercial purposes it is produced in rectangular blocks, then cut into sheets, and then vulcanized by the action of sulphur or some compound of that element, in order to harden it, which prevents heat or cold materially affecting it. Most of the rubber now manufactured is not combined with sulphur in the sheets, but is mechanically incorporated with it, with about one-tenth of its weight with that substance, by means of mixing rollers.

Rubber Goods.—Ordinary mackintosh or waterproof cloth is prepared by spreading layer after layer of India-rubber paste on the textile fabric. Sulphur is used with the paste when cotton or linen is to be covered. Double-texture goods are made by uniting the rubber surfaces of two pieces of the coated material. Rubber hardened by over-vulcanization becomes ebonite or vulcanite, and is made by incorporating about 40 per cent. of sulphur with purified Borneo rubber. There is an endless number of goods produced by India rubber, and its utility is rapidly increasing.

Other Uses of Rubber.—One of the most important uses of rubber is for tires for vehicles. At the outset rubber tires were suspiciously regarded, but experience has demonstrated their great value, economy and comfort. This demand creates a very large and steadily increasing outlet, and the vehicle industry has been much benefited by the adoption of these yielding tires. The production of rubber goods is by no means restricted to localities, although the industry prospers particularly in Rhode Island, Ohio, New York and two or three other States. In Rhode Island, for instance, the production of mechanical rubber increased threefold during the past decade. In Ohio, and especially at Akron, the rubber-tire industry is exceptionally prosperous. In New Jersey, where special attention is given to mechanical rubber goods, production has trebled during the last decade, and it ranks as the second industry in the State.

The demands of the bicycle industry years ago constituted an important factor in its development. This was followed by the demand for rubber tires for almost all manner of vehicles, from the lightest to the heaviest. Tires seven inches and more in diameter are now regularly manufactured, and their use is found to confer advantages which are permanent. The industry is practically in its infancy.

Manufacture of Rubber Goods.—The manufacture of rubber goods was first undertaken on an extensive commercial scale at Roxbury, Mass., in 1833, by John Haskins, Edwin M. Chaffee and Luke Baldwin. They first made cloth for carriage tops, but as the material was not vulcanized, the products were not durable. Nathaniel Hay almost anticipated the great Goodyear discovery, but he overlooked to subject the rubber to a mixture with sulphur at an intense heat. Instead, he only rubbed powdered sulphur on the exterior of the goods. Charles Goodyear, in 1838, began with Hayward to experiment. By a mere accident Goodyear dropped a bit of sulphur on a hot stove, and found that it became absolutely vulcanized. This was the foundation of the Goodyear patents. His first patent was secured in 1844, and in all there were fifty. He won medals at all foreign exhibitions, and received the ribbon of the Legion of Honor in France. Large factories soon were built to operate on the basis of his patent.

Statistics.—In Massachusetts, in 1890, there were 50 establishments, employing 3,472 workers; value of products, $8,518,612. In 1900 the number of establishments had increased to 70, and showed an increase in value of products of 68.4 per cent. In New Jersey the rubber industry increased, as measured by its production, from $1,303,000 in 1860 to $6,322,569 in 1890, and $8,458,274 in 1900, while in Rhode Island the expansion of the industry in the single decade of 1890-1900 was threefold, as measured by output.

Comparative Summary of the Rubber and Elastic Goods Industry.

	1880	1890	1900
Number of establishments	90	139	262
Capital invested	$6,057,987	$13,703,787	$39,304,853
Wage-workers	6,268	9,183	20,405
Wages paid	$2,295,972	$3,663,976	$8,082,738
Value of products	$13,751,724	$18,708,917	$52,627,030

Inks and Ink Making.

Composition of Inks.—Inks may be classed under four heads—writing, marking, copying and printing inks. Writing ink consists either of colored liquids or colored precipitates suspended in a liquid. The requirements of a good black writing ink are an infusion of best nut gall, copperas and gum. In making ink it is necessary to leave the mixture to itself in order that certain chemical action may take place, after which gum is added to retain in suspension the elements of the ink. In some inks a solution of logwood is used which makes them sufficiently fluid. Red ink is a solution of cochineal in ammonia, or of brazil wood in water. Blue ink is a solution of Prussian blue and oxalic acid in water; chrome ink is made of logwood and potassium bi-chromate.

Marking Inks.—Marking ink consists of a solution of silver nitrate colored with lamp black and thickened with gum. It must be able to withstand the action of soap, alkaline and acid liquids.

Copying Ink.—Copying ink may be prepared by adding a little sugar or glycerine to ordinary black ink, but it must be thicker, and care must be taken that ingredients are used to prevent it drying too quickly.

Printing Ink.—Printing inks consist essentially of well-boiled drying oils mixed with lampblack or other pigments, to which soap and resinous matters are sometimes added, but there are other radically different processes in which other materials are used for printing house requirements.

In the manufacture of ink a varnish is often used which is obtained by boiling linseed oil. Colored inks are made from this varnish by adding pigments to produce any and all colors desired.

Indelible Ink.—An indelible ink can be made by adding to gall ink a strong solution of fine soluble Prussian blue in distilled water. The ink writes greenish blue, but afterward turns black.

Invisible Ink.—Invisible or sympathetic ink is a solution of sugar of lead in pure water. Written characters are then held over a jet of sulphuretted hydrogen, developing an intense black color. Sulphate of copper in a very dilute solution will produce an invisible writing which will turn light blue by the vapors of ammonia.

Restoration of Ink.—Faded ink can be restored by brushing over the writing with a solution of sulphide of ammonium.

The production of many of the ordinary commercial inks is conducted by improved process, embodying the use of special machinery, in which the raw material is handled in large quantities, and by which very material reductions have been made in cost.

Aniline Inks.—Aniline inks are variously made. One basic method consists in dissolving aniline colors in strong alcohol to which water is subsequently added, then gently heated, after which a solution of powdered gum arabic and water is added.

Ink-Making Methods.—In the making of black inks, borax and shellac are used as well as logwood shavings, powdered gall, green vitriol, crystallized sulphate of iron, sulphate of iron, liquor of ammonia, spirits of wine, vinegar, etc. These materials, as well as many others, are used in varying proportions, according to established methods, the result of long experience. There is no end to formula and to the methods employed. Blue inks are made with oxalic acid, gum arabic, Chinese blue, Paris blue, vitriol, indigo and other materials, all of which are used according to certain formula and subject to well-defined process.

Varieties of Inks.—Among the special varieties of inks are bookbinders' inks, burnishing inks, cancelling ink, carbon inks, chrome inks, endorsing inks, exchequer inks, frost-proof ink, gluten, green, gold, incorrodible and indelible inks, indestructible inks, India inks, Japan inks, lithographic inks, pharmaceutical inks, printers' inks, and a vast variety of other inks, available for all purposes to which inks are applied.

Receipts for Making Inks.—Ink can also be made as follows: 600 parts distilled water, 800 parts lime water, 100 parts logwood, 25 parts common hydraulic acid, 3 parts carbolic acid and 3 parts bichromate of potassium. The process of making is to dissolve the extract part in the lime water in an enameled vessel, then add the carbolic acid and hydraulic acids. After a half hour's heating over a steam bath, let it get cold and strain. Next add bichromate of potassium to the gum, each separately dissolved in distilled water; then add enough distilled water to make the whole equal to 1,800 parts. This ink is at first red, and then turns black.

Ink Receipts.—Receipts for making ink are many. A good black ink may be made of 1 part of concentrated solution of borax, 4 parts shellac, boiled, to which some aniline black should be added.

Arnold's writing fluid is a mixture of sulphate of indigo and ordinary ink.

Another ink can be made by powdering coarsely 2 pounds gall nuts, $1\frac{1}{2}$ pounds iron sulphate, 7 ounces gum arabic. To this add 2 quarts vinegar and $3\frac{1}{2}$ gallons of water. The mixture should be stirred frequently and let stand eight to ten days.

A very fine ink is made of 11 parts galls, 2 parts green vitriol, $\frac{1}{7}$ part indigo solution and 33 parts water.

A very black ink is made of 30 parts extract of logwood dissolved in 250 parts water, 8 parts crystallized carbonate of soda and 30 parts glycerine of a specific gravity of 1.25. Add 1 part neutral chromate of potash and 8 parts gum arabic reduced to a powder and dissolved in water.

An ancient Egyptian ink of great merit is made of a solution of borax in water and pure lampblack. This ink is indestructible by time or chemical agents.

The numerous ink-making processes of the past twenty-five years have been simplified into a few by which the great bulk of the standard and commercial inks are produced.

Comparative Summary of the Ink-making Industry in the United States.

	1880	1890	1900
Number of establishments...	63	73	104
Capital invested............	$1,251,050	$2,655,219	$3,821,514
Wage-earners	480	761	787
Wages paid.................	$230,284	$420,228	$412,140
Value of products...........	$1,629,413	$3,504,979	$4,372,707

Irrigation and Hydraulics.

The Coming Problem.—The subject of irrigation and hydraulics is the next mighty problem to which the attention of a large number of people of the United States will be directed. The reasons therefor are that there is a large area of arid land throughout the West and Southwest, which is not susceptible to cultivation. Population is growing rapidly, newcomers are pressing close onto the borders of this vast desert or semi-desert, agriculture is being stimulated, farm products are wanted by the world, railways desire freight traffic, cultivators of the soil desire new land to cultivate. The attention of large numbers of people is directed to the possibilities of bringing upward of 600,000,000 acres of land now of no practical value under the dominion of agriculture.

Force of Public Opinion.—Public opinion and public necessities have induced Congress to take practical measures to lead in and aid the restoration of this valueless area to the demands of the country. Private enterprise has, during the past ten or twenty years, accomplished much in the reclaiming of portions of this region, the profits of which have still further stimulated private enterprise in that direction but the magnitude of the project is such that nothing less than government action can cope with this work.

Irrigation Conventions. — Various conventions have been held within the past decade in which the subject of irrigation has been discussed. Hydraulic engineers have studied the problem thoroughly, numerous surveys have been made, and many estimates have been figured out as to the approximate cost of the work. At a recent convention, September, 1903, in Salt Lake City, which was composed of the foremost men in the United States in finance, in commerce, in banking, railroads, mining and agriculture, measures were drafted for the early undertaking of this work upon a scale of magnitude commensurate with its vast importance.

The value of such work cannot easily be estimated. At an estimate of even $10 per acre it would add a value of $6,000,000,000 to the basic wealth of the country.

Necessity for Irrigation.—In view of the extraordinary demand for American cereal products and for orchard and vineyard fruits, and in view of the vast mineral deposits known to exist in portions of this area, there is every reason for governmental action in placing this land within reach of legitimate enterprises.

General Plans Completed.—Hydraulic engineers have formulated plans of vast magnitude which embody the impounding of the waters of the Rocky Mountains at convenient points and of conducting it by means of ditches and canals to the arid section and there distributing it in smaller streams to supply the requirements of the individual farmer. These plans have met with the approval of the highest engineering skill and it appears to be only a matter of dollars and labor to reclaim a vast section of worthless land to the agriculturists, miners and manufacturers.

Iron and Steel, Workers in.

Growth of Iron and Steel Making.—No industry on the American continent has advanced with such rapid strides during the past fifty years, and especially within the past twenty years, as the iron and steel industry, as measured by capital invested and quality and volume of product. Iron is sometimes spoken of as the barometer of trade. It might as truthfully be spoken of as the barometer of Civilization. The per capita annual requirements of the people of the United States are 500 pounds of iron and steel. Within practically one generation enough railroad track alone has been constructed in the United States to go around the earth at the equator six times. The isolated efforts of the iron industry, creditable as they were in the early decades of the last century, did not assume pronounced shape until the little forges at Pittsburg began the rolling of bar iron in a limited way in competition with the products of English mills. For a long time the contest was an unequal one.

Railroad Demands.—The construction of railroads constituted the first epoch in the iron and steel industry. Iron rails were used, and they were mostly imported. Back in the early fifties the Cambria Iron Company was established at Johnstown, Pa., at one of the foothills of the Allegheniés, and supplied railroad builders with iron rails to the extent of their limited capacity. The early efforts of the iron workers were chiefly directed to the production of bar iron and nails and to the production of foundry iron for castings and other purposes, and, to a limited extent, of steel for tool and similar purposes, for use in the mechanical arts and in construction.

Multiplication of Mills.—Bar mills and nail factories sprang up in various localities, the most notable centers prior to 1850 being at Pittsburg and Wheeling. With the expansion of manufacturing, bar mills grew in number and capacity; nail factories sprang up alongside, sheet mills began to compete with foreign like products, and plate mills found an active demand for material from boiler shops. When railroad construction became an important factor, iron rail mills sprang into existence to supply the demand for rails, and with the construction of high buildings—which the elevator made possible—the demand for steel for girders, angles and beams arose.

Railroad Development.—This marked the opening of the agricultural implement industry, to which the merchant-steel industry contributed so much; in fact, without steel, that great industry would have been a practical impossibility. Then came pipe and tube mills, rod mills, mills for the manufacture of wire nails from rods at a speed and with an economy of production that vastly extended their use. Each of these industries naturally and gradually became more and more diversified, each branch becoming a component industry, as it were, and carrying in its wake a number of minor industries, thus constituting a great webwork.

Second Great Epoch.—The second epoch came with the opening of the Civil War. With the enactment of the Morrill tariff of 1861, which greatly restricted iron importations, a stimulus was imparted to the iron industry. The extraordinary necessities of the war attracted capital, and rolling mills began to multiply in localities in Pennsylvania and Ohio, where fuel was available at low cost. Mechanical ingenuity soon discovered strong incentive to devise labor-saving appliances, which at the same time resulted in a greater production at comparatively small expense. The puddling furnace as it was built in England was used. Blast furnaces began to be erected, of small capacity. From the early small furnaces of 100 to 300 tons of pig-iron producing capacity per week, furnaces were remodeled, until now furnaces of from 500 to 700 tons per day and over are ordinary achievements.

The Third Great Epoch.—The third epoch in the iron industry was the development of the Lake Superior ore region, which contains a vast deposit of ores of the hematite variety, especially valuable for steel making. In fact, the foothold of the steel industry was in the Lake Superior ore region. The astounding development of this industry would have been held in check, had it not been for the discovery and development of the largest and purest deposit of coking coal in the world, in the famous Connellsville region, sixty to seventy miles southeast of Pittsburg. With the richest iron ore in the world, averaging 65 per cent. metallic iron, and the purest coke in the world, practically free from sulphur and other deleterious elements, the steel industry sprang into vigorous life. But for these two mighty factors, the construction of the great railway system of the United States, now aggregating 210,000 miles of road, would have been of very much slower growth, if not impossible.

Discovery of the Bessemer Process. — But the greatest epochal event in the development of the steel industry was the discovery and application of the Bessemer steel process, the work of Sir Henry Bessemer. This process consists essentially of forcing air through molten pig iron at high temperature, in which the oxygen of the air chemically takes up the impurities or "foreign" ingredients in the molten metal, instantly, so to speak, transforming it into (Bessemer) steel, the steel of which railroad rails are made.

Open-Hearth Process.—Second in importance to the Bessemer process, and vital in its influence on the steel industry, is the open-hearth steel process. By this process large quantities of steel are rapidly produced, which answers various special purposes.

Steel Billets.—Steel is ordinarily made into billets, then rolled into forms and sizes for specific use, such as plates and structural shapes for bridge building, engine and boiler and car construction and an almost endless variety of purposes. Much of this material is converted into pipes, tubes and material for electric traction roads and an almost endless variety of shapes used in the agricultural implement industry, to say nothing of hardware, cutlery, etc.

Mining Appliances.—The mining or quarrying of ore in the Lake Superior region has developed a number of economic appliances for rapid handling from the ore beds to the cars, thence to boats, thence across the lakes, and thence by rail to the furnaces. Cars of great capacity are used, with devices for quick unloading. Steam shovels are used at many mines, which simplify the primary work. Boats and ships of immense tonnage capacity are employed to carry the ore to its destination. These ores are classified and sold according to chemical analysis and constituents, and are used according to their utility for the various purposes to which iron and steel are applied.

Limestone Flux.—Limestone is used for fluxing purposes in the blast furnace. In 1902, 9,490,090 tons were used. The average consumpton of limestock per ton of all kinds of pig iron produced was 1,192.8 pounds, or a little over one-half ton. Of the total production of pig iron in 1902, over 58 per cent. was Bessemer and low phosphorus, showing the remarkable strides which the industry made in a few years.

Steel Statistics.—The open-hearth steel plants in 1902 numbered 98, scattered over 16 States. This steel is made by two processes, known as the acid and basic processes. The basic process is much more general, the increase of basic in 1902 being 24 per cent. over 1901, and of the acid process 15 per cent.

The production of open-hearth steel castings in 1902 was 367,879 tons. This process greatly reduced the cost of castings, and thus contributed to the expansion of their use.

The production of crucible steel in 1902 was 112,772 gross tons, and of all kinds of steel castings 390,935 gross tons, of which 39 per cent. was produced in the State of Pennsylvania.

Versatility of American Workmen.—The wonderful adaptability and versatility of the American workman has been perhaps nowhere else so boldly exhibited as in the iron and steel industry. In magnitude of equipment, and in variety of mechanical adaptations, and in the development of labor-saving devices, and in the rapidity with which metallurgical operations are conducted—all in strict accordance with chemical and mechanical laws governing the constitution of matter—the steel and iron mills of the United States have no equal. Tubal Cain would be a stranger among them. The steel industry is the backbone of American industries. Its development has been, if not the cause, at least the companion of numerous lesser developments in agriculture, mining, railroad building and in the creation of the unparalleled congeries of manufacturing industries which constitute the warp and woof of the economic structure of the United States. A volume could not record the achievements and transformations and opened opportunities for investment of capital and the employment of labor and the developments of skill in the manipulation of steel, which makes it available for a steadily increasing number of uses.

Metallurgists and Skilled Workers.—The gulf between the brown stone in the bowels of the earth and the keen, glistening razor edge is quickly leaped over by scientific metallurgy and skill and the skillful manipulation of intelligent and observing workers. The steam shovel drags the hidden ore to the sunlight, the blast furnace forces it to part company with its useless companions, the furnace elevates it into almost a comprehension of its existence, and the rolls and shears graduate it for entrance into the great world of the mechanical arts.

Something About a Blast Furnace.—The modern blast furnace, often spoken of as a stack, might be compared to an enormous bottle, 80 to 100 feet high, 20 to 25 feet in diameter at its widest part, which is about 25 feet from the base, from which point it tapers both ways. The top, where the material is fed in, is called the throat, the lower part the boshes, and about 4 feet from the bottom are the tuyers, through which the air blast enters. Each ton of iron requires from 3 to 6 tons of air, which is forced into the furnace by immense air compressors, under a pressure of from 5 to 10 pounds per square inch, heated to a temperature of 1,500 degrees Fahr.

Materials Used.—Iron is made by the use of iron ore, coke or coal, and limestone, which are successively emptied in in fixed proportions. The coke or coal furnishes the heat, the limestone the flux or what corresponds to soap in domestic operations. It assists in separation of the iron in the ore from its earthy constituents. The furnace is metallurgically divided into three zones, which merge one into the other, and as the material descends from one zone to the other, the oxygen, carbon, silicon, sulphur and phosphorus all separate and form, aided by the enormous in-blast of air, which intensifies combustion.

The ore first gives up its oxygen, forming carbonic acid; descending to the next zone, the iron takes up carbon. Manganese is used to increase the power of carbon to unite with iron. Phosphorus clings to the iron as it passes down, and the heat in the lower part of the furnace reaches a temperature of from 3,500 to 4,000 degrees. Here the iron has absorbed 4 or 5 per cent. of its own weight of carbon, and the foreign matter driven off from the fuel, ore and limestone is known as slag, floating on the surface of the molten iron, where it is drawn off. The tapping hole is then opened and the pure iron (pig iron) flows out into prepared receptacles, where it hardens and is pried up before solidifying, or is permitted to solidify in specially constructed beds recently introduced, when it becomes the pig iron of commerce.

Open-Hearth Steel Making.—Open-hearth steel is usually made in a regenerative furnace lined with fire-brick and having an acid or a basic bottom. A mixture of pig iron of certain quality and steel scrap is melted, then tapped with a ladle, a certain amount of spiegeleisen or ferro-manganese being added in the furnace or ladle to furnish the desired percentage of carbon. From thence it is run into ingots or castings. Artificial or natural gas is used in melting.

In 1872, 5-ton open-hearth furnaces were put into operation at Nashua, N. H., and Pittsburg, Pa. Basic open-hearth steel was made in Cleveland, Ohio, in 1886, and at Homestead, Pa., in 1888, when melting capacity per heat was from 7 to 10 tons, which by 1890 was increased to from 20 to 30 tons, and in 1900 to 50 tons, though one plant is using a 75-ton furnace.

Capacity.—In 1900 there were 44 open-hearth steel works, with an annual capacity of 165,529 tons; 40 crucible steel works, with 2,619 pots, with an annual capacity of 104,393 tons, which had a market value of $7,286,882. Of the entire steel-ingot production in 1900, 71.6 per cent. was Bessemer, 27.4 open-hearth and 1 per cent. crucible steel.

Billets and blooms made directly from iron ore are largely used in the manufacture of crucible steel, while billets and blooms made from pig iron and from scrap and steel are rolled into plates, sheets, skelp and rods, and are used to make boiler tubes, boilers, screws, rivets, wire, etc.

Bessemer steel was first produced in commercial quantities in 1867, and by 1880 eleven rail mills were in operation. This steel is used for making steel rails.

Comparative Summary of Blast Furnace Production.

	1880	1890	1900
Number of establishments...	341	304	224
Capital invested............	$89,531,362	$134,608,543	$148,226.113
Wage-workers	41,695	33,415	39,358
Wages paid..................	$12,655,428	$14,614,458	$18,500,462
Value of products...........	$89,315,569	$145,643,153	$206,823,202
Production in tons..........	3,375,912	8,845,185	14,452,234

The production of charcoal pig iron fell from $19,268,747 capital invested in 1880, to $6,155,839 in 1900; workmen engaged, from 16,670 to 1,623 the same years; wages paid, from $4,101,276 to $562,420; value of products, from $12,575,996 to $5,344,515.

The great iron and steel industry has expanded to phenomenal proportions during the past ten years, and enormous expenditures are still being made to increase productive capacity. In no other industry is there such activity, and the high water mark of demand appears to have been reached.

Comparative Summary of Rolling Mills and Steel Works at Work.

	1880	1890	1900
Number of establishments...	358	395	438
Capital invested............	$116,458,390	$278,559,831	$441,795,983
Wage-workers...............	96,164	137,295	183,023
Wages paid................	$41,880,687	$74,460,433	$102,238,692
Value of products...........	$203,274,042	$321,860,872	$596,689,284
Tons of steel rails, rolled....	670,161	1,853,862	2,250,457
Iron and steel bars..........	874,144	1,572,347	2,493,159
Iron and steel wire rods.....	....	....	916,587
Hoops, bands, cotton ties and skelp.....................	201,039	546,203	1,195,189
Armor and boiler plate, etc..	262,063	652,693	1,488,066

Summary of Daily Capacity of Rolling Mills and Steel Works—including Idle Establishments.

	1880	1890	1900
Number of establishments...	391	429	476
Daily capacity (tons)........	19,730	41,576	90,122
Bessemer converters........	24	97	91
Daily capacity (tons)........	3,988	19,285	38,420
Open-hearth furnaces.......	37	129	331
Daily capacity (tons).......	738	3,608	19,030
Crucible pots...............	2,691	2,606	2,619
Bloomeries and forges......	93	20	7
Capital invested............	$3,915,213	$876,470	$508,388
Wage-workers...............	2,939	471	226
Value of products...........	$3,968,074	$1,183,494	$522,432

Comparative Summary of Iron and Steel Making Industry.

	1880	1890	1900
Number of establishments...	792	719	669
Capital invested............	$209,904,965	$414,044,844	$590,530,484
Wage-earners...............	140,798	171,181	222,607
Wages paid................	$55,451,510	$89,273,956	$120,836,338
Value of products..........	$296,557,685	$478,687,519	$804,034,918

Iron Ore Mining.

Production of Ore.—The production of iron ore in the United States in 1870 was 3,031,891 tons; 1880, 7,120,362 tons; 1890, 16,036,043 tons; 1900, 27,553,161 tons, since which time it has been increasing.

Lake Superior Output.—Of this the Lake Superior region produced, in 1870, 830,940 tons; 1880, 1,908,745 tons; 1890, 9,003,729 tons; 1900, 19,059,393 tons. This great region furnishes the largest and richest supply of ore in the world, much of it lying near the surface and easily mined. Its present limits are now pretty well defined, and aggregate somewhat over 1,000,000,000 tons, of which the United States Steel Corporation controls about 800,000,000 tons, which has an estimated market value in the ground of $1 per ton.

Mining Facilities.—The facilities for mining have been greatly improved in recent years by the introduction of appliances for dislodging the ore from its native bed and handling it by means of steam shovels to place it in cars which are brought close to the mines.

Some deposits are reached by shafts, in which most complete and powerful machinery is employed to lift the ore to the surface, from whence it is carried in cars of large capacity to lake shipping ports, and frequently loaded direct into vessels, and sometimes stored on docks to await transportation. Vessels of from 5,000 to 7,000 tons' capacity, as well as smaller vessels, carry this ore from the docks to distributing points, and which is unloaded by specially devised machinery which unloads several thousand tons in a few hours.

Richness of Lake Ores.—Lake ore is exceptionally rich in metallic iron, much of it averaging 65 per cent. It is hurried to blast furnaces, mainly located in Pennsylvania, Ohio and Illinois, where it is converted into pig iron by the aid of limestone and fuel, in furnaces some of which produce as high as 700 tons per twenty-four hours, thus calling for the conversion into their elements of some 2,000 tons of material per day. The blast furnace in one respect might be regarded as the greatest material agency in modern civilization.

Statistics.—The world's production of pig iron in 1901 (the latest obtainable figures) was 40,356,000 tons, of which the United States contributed 39.34 per cent.; Great Britain, 19.65 per cent.; Germany, 19.48 per cent., and France, 5.92 per cent.

The world's production of steel for the same year was 30,680,000 tons, of which the United States produced 43.92 per cent.; Great Britain, 16.30 per cent.; Germany, 20.84 per cent.; France, 4.78 per cent.

Jewelers and Jewelry.

Gold in Jewelry.—A review of the jewelry industry and survey of the occupation of the jeweler very properly begins with a reference to gold, though that metal does not constitute the only basis of the jeweler's art. Its specific gravity is 19; atomatic weight, 196; melting points between 1200 and 1400 C. It has always been held in high estimation by mankind because of its lustre, freedom from oxidation and the facility with which it is wrought into artistic shapes. It is found in its native state in grains, spangles, crystals, minute fibres, lumps and nuggets, and occurs in the older metamorphic and slaty rocks in steditic, talcose or chloritic rocks, in quartz beds and veins which penetrate them. It is never found in solid veins, but associated with other metals. A theory is held that the slates which contained the original gold were deposited as mud and settled on the ancient sea bottoms, which subsequent upheavals and various unknown influences dissolved and precipitated in existing veins. More or less of this fissure gold came from primordial rocks. Subsequently the sulphurets, which principally carried the gold, were dissolved by atmospheric action and later on rains and other denuding agencies carried it to gravel beds, which occurred just before and after man's appearance on the earth. Sea water contains, according to some estimates, one grain to the ton of water, which would give a dollar's worth of gold to twenty-five tons of sea water.

Where Gold was Found.—The early American Indians knew of gold, as the evidences of an ancient mining village, with rude mining tools found nine feet beneath the surface in Nacooche Valley, Georgia, show. Early in the last century the famous Cabarrus nugget, weighing 28 pounds, was found in the Reed mine, North Carolina. Cortez found gold in Southern California in 1537. Drake in upper California in 1577, but it was Marshall's discovery in 1848, at Sutter's mill race, in that State, that led to the great rush. The washing of gravel was followed by hydraulic mining and in 1860 vein mining began.

Influence of Gold.—An important event was the discovery of the Comstock lode, which was worked at an average depth of 2,000 feet. Following this find, gold seekers spread all over the Pacific coast and Rocky Mountain region from Mexico to Alaska. The influence of gold production here and elsewhere in the world of business is beyond definition. As a medium or basis of exchange, it has made industry and commerce possible on a scale of magnitude beyond all calculation.

Early History.—The jewelry industry has no "center." Its early development shows that hand methods prevailed exclusively. Way back in Colonial history the jeweler was an active and highly appreciated mechanic. It was in 1784 that a Providence (R. I.) goldsmith laid the foundation of the industry in that city, which has since become famous for the magnitude, variety and artistic beauty of its work. While jewelry manufacturers in all the cities were turning out gold and silver products by hand, Nehemiah Dodge invented a process for "filling," which might, perhaps, be incorrectly termed the first epochal event in the manufacturing process. This process cheapened jewelry and opened up a larger demand for it, which influence in turn started the inventive talent of New England machinists, and in a few years quite a number of ingenious machines were devised and installed. Providence soon became known as a jewelry center, but Attleboro, Mass., soon became somewhat of a rival.

"Cheap" Jewelry.—An interesting feature of no ordinary significance in the jewelry industry was the introduction of "cheap" jewelry. Much of the cheap jewelry is now produced in Providence, Attleboro and North Attleboro. The industry at Attleboro began in 1805. The products of the early establishments were chiefly silver spoons, gold beads and finger rings; afterward some of them branched out into the manufacture of cheap gold jewelry, silver and other alloys being largely used with a fraction of gold, while large articles were plated by the hammering process.

Filling Process.—A skillful worker in gold in Birmingham, England, one Thomas H. Lowe, in 1846, brought with him an improved filling process which was immediately adopted and resulted in a marked reduction in cost of working. Lowe's process introduced the manufacture of rolled plate jewelry by sweating the thin plate of gold on the substratum of base metal before it was rolled out. This was simpler, better and more economical and still further cheapened the cost to consumers. His plan was to place a sheet of gold on a copper base, hammer it down on an anvil and draw it out still thinner with hand rolls. Since then this process has been improved and has been followed by a number of devices for cheapening and improving the work.

Seamless Wire.—Levi Burtion introduced seamless wire, which was of a vital character in that it worked a revolution in styles and vastly improved the qualities of jewelry. By this process wire drawn to any degree of fineness desired, is covered with gold. There is no seam to open up and disclose the true character of the material.

Providence, R. I., in the Lead.—As gold and silver increased in abundance the industry and trade of the jeweler expanded. Providence maintained its lead. The first authentic figures go back to 1812, when the value of products reached $100,000. In 1856 they were valued at $2,646,000; in 1900, $8,889,702. During the last decade the output increased 66 per cent.; over one-fifth of the jewelry produced was made in that city. New York, Newark and Philadelphia followed in importance.

Silverware.—An apprentice of the founder of the jewelry industry in the United States established a silverware industry in Providence. In 1890 nearly one-half of the silverware manufacturing done in the United States was done in Rhode Island, and in the last decade the production increased 70.8 per cent., due in some degree to the cheapening cost of silver. At the present time the industry is under stimulating influences, due to the low cost of silver and the increasing supply of gold. It is also influenced by the increasing production of diamonds and other precious stones. No more powerful influence has been imparted to this industry than the supply of diamonds from South Africa. Seekers after precious metals are now found in all parts of the world, gathering material for the jeweler, whose skill, taste and good judgment effect combinations which charm the eye.

Influence of Jewelry.—Aboriginal taste and the taste of the most highly cultivated unite in jewelry if nowhere else, the chief distinction being in the manner and degree of use. That the use of jewelry will rapidly grow needs no confirmatory evidence beyond that afforded by the display offered by the increasing numbers to whom the lower cost makes it available. That jewelry has a refining, and in an indirect way, an educational influence, need not be argued. It is the natural and appropriate accompaniment of good dressing and insensibly surrounds the user with an "atmosphere," for want of a better word, of superiority, if the phrase be permitted, which is not without its commendable features. A bejeweled person instinctively feels under certain invisible bonds to conform in manner and conduct to the ideal significance of the jewelry worn.

Gold and Civilization.—There is a politico-economical aspect to gold and silver, which, while it has no direct bearing upon the jeweler and his trade, deserves a passing reference. Certain writers profess to have discovered a certain historic relationship between the increase in the volume of gold and the progress of civilization. Certain other writers are able to point out the sudden upheavals of the commercial and industrial and even the educational spirit with the discovery and utilization of gold supply. Without passing judgment on these views, it may be safely said that in our time the supply of gold appears to be closely related to great activities in trade channels. The exchange of products appears to be stimulated by stable values and a larger supply of the material through which values are represented. Commercial depressions have been apparently explained as due to an inequality between the supply of gold and the bounding and absorbing activities of the people. The discovery of gold in California in 1849, though followed eight years after by the panic of 1857, opened up activities which distinguished the decades of 1850-1860 from previous decades. The later discoveries of gold have, doubtless, added much to the capacity of the people of the world to do. The enormous accentuation in production in recent years can be fairly credited with much of the "prosperity" which is being enjoyed, though the factor of abundant crops should not be lost sight of in dealing with this more or less problematical assumption. That the anticipated yield of $400,000,000 gold per annum will soon be reached and then steadily exceeded is a reasonable anticipation with all the results upon the world's activities which recent and more remote experience warrant us to look for.

Comparative Summary of the Jewelry Industry in the United States.

	1880	1890	1900
Number of establishments...	739	783	908
Capital invested............	$11,431,164	$22,246,508	$28,120,939
Wage-earners................	12,697	13,880	20,676
Wages paid..................	$6,441,688	$8,038,327	$10,746,375
Value of products...........	$22,201,621	$34,761,458	$46,501,181

Jute Goods Making.

From What Made.—Jute is made from the fibre of two Indian plants cultivated in the central and eastern parts of Bengal and in the neighborhood of Calcutta. It is manufactured into cloth of different qualities, ranging from a substitute for silk shirtings to curtains, carpets and gunnies, which are bags for holding grain and other products. Jute paper is also prepared from the rejections and cuttings of mills; cordage from the coarser and stronger qualities.

European Efforts.—The fibre was first experimented upon by Europeans in 1820, but without commercial success. The manufacture was introduced into Dundee, Scotland, and carried on by the aid of machinery. The competition in time greatly injured the India hand manufacture, but the natives found it profitable to export the raw material. After this factories were established in

India and Borneo, and nineteen sprang up near Calcutta between the years 1864 and 1882. Jute is now grown successfully in some parts of the United States, yet jute goods are very largely imported for the manufacture of gunny bags. Jute balts, which take in the lower part of the stem and the upper part of the root, are also imported largely. Machinery is now being developed which will render the United States independent of foreign jute.

Comparative Statement of the Jute Industry.

	1880	1890	1900
Number of establishments..	4	7	18
Capital invested.............	$415,000	$1,645,636	$7,027,293
Wage-earners...............	525	1,194	4,506
Wages paid...................	$141,979	$368,585	$1,181,790
Value of products...........	$696,982	$1,120,121	$5,383,797

Kaolin Industry.

Origin of Kaolin.—Kaolin, the raw product from which porcelain is mainly produced, sometimes called China clay, is, according to the language of chemistry, a hydrated silicate of alumina. It was first found in China in a hill locally known as Kauling, from whence it obtained its name. It is derived principally from the decomposition of feldspars of granites and felsitic rocks. The name kaolinite was applied to a soft powder made of the minute pearly scales always present in kaolin.

Manipulation.—Its manipulation in potteries is an interesting process, in the development of which chemical knowledge is displayed, as well as keen mechanical ingenuity.

Comparative Summary of the Kaolin Industry.

	1880	1890	1900
Number of establishments...	63	95	145
Capital invested.............	$1,291,527	$3,334,575	$12,212,341
Wage-earners...............	898	1,271	2,094
Wages paid...................	$310,909	$548.879	$820,678
Value of products...........	$1,455,757	$2,846,862	$3,722,151

Lamps and Lamp-Making.

Early History.—Lamps had come into general use for domestic purposes in Greece as early as the fourth century B. C. Long before that time they were in use in temples, where it was the custom to keep them burning constantly. Herodotus tells us of the "festivals of lamps," which were held at Sais, in Egypt. Many of the temple lamps were extraordinary specimens of workmanship and artistic beauty. The common sort of domestic lamps were made of terra-cotta and shaped somewhat like an elongated fan, which had a spout or nozzle in which the wick burned. The oil was poured in at the top, and it was made with a stout handle by which it could be easily carried. Many had numerous holes for wicks. Ornamentation was a conspicuous feature, and it was confined to the handle and the oval upper surface. These ornamentations show a high degree of skill on the part of the ancient craftsmen. The designs appeared in relief and were taken from mythology, legend, from objects of daily life or from gladiatorial combats or chariot races, etc. Many lamps were made of more or less fantastic shape, taking, perhaps, the form of an animal, bull's head or human foot. The usual colors were a red or black glaze which would resist heat. The bronze lamps were made of the same general shape, having a ring for the forefinger and a place for the thumb to press. They had a cover to protect the flame from the wind, as they were largely used out of doors. In some respects they bore a resemblance to the modern lantern. The lamps made for suspension were highly ornamented on the under surface. Fine flax was often used as wicks, and in some cases lamps were used for measuring time.

Defect in Early Lamps.—The chief defect of ancient and of modern lamps down to the eighteenth century was that they threw light only forward and sideways. Inventive talent did not seriously address itself to lamp construction and to its lighting qualities until about 1783, when Leger, of Paris, produced a broad, thin flame with no core, so that all parts of the oil supply were brought into contact with the air.

The Argand Lamp.—The first decided improvement was made in 1784, by Arni Argand, of Paris, who adopted a curved form of burner consisting of two concentric tubes or cylinders, between which the tubular wick is contained. It was called the "double-current" burner. But an improvement was needed by which the outer current supplied to the outer circumference of the flame could be strengthened and regulated. This was done by means of a chimney, which was first made of sheet iron and afterward of glass. Next a shoulder was made on the chimney, by which the air current was directed inward against the external surface of the flame. Argand's original burner was the parent of the almost innumerable modifications since.

Later Improvements. — The lamp invented by Franchot about 1836 had a strong spiral spring by which the oil was propelled to the burner and a tube through which the oil passed upward to the burner. Lamps for mineral oil came into general use after the introduction of paraffine oils and petroleum. The duplex burner, introduced in 1865, had two or more single flat wicks, and rapidly superseded others. Tubular wicks were supplanted by flat wicks, which were made to form in effect a circular wick. Numerous and valuable improvements have been made in recent years, known by a variety of names.

Features of Lamps.—The qualities of a lamp are to be judged of by brilliance, steadiness, uniformity of light yielded in proportion to the quantity of oil consumed, by the position, form, portability and convenience of the lamp itself.

Other points to be considered are: Means of supply and regulation, form and management of wick, regulation and control of the current of air and position of the oil reservoir in relation to the dissemination of light.

Mining Lamps.—One of the important branches of the lamp-making industry is that of manufacturing mining lamps, in which great proficiency has been attained. The work is subdivided into several branches, each branch being in a sense a separate trade. The work of the mechanic is measurably facilitated by special mechanical devices. The modern lamp factory, with its skilled workmen, represents a high development of mechanical art. Among the best-known lamps are the Davy, which differs only in size and shape of the oil cup; the Beard-Mackie safety lamp, the Clanny lamp, the Wolf lamp, the Frieman & Wolf lamp, the Marsault lamp, the Mueseler lamp, which increases the draft and prevents smoking; the Ashworth lamp, in which the flame is surrounded by a conical glass chimney; the Gray lamp, which has a solid metal chimney; the Ashworth-Hepple-White-Gray lamp, the Pieler lamp, which burns alcohol; and the Dick, Mauchlone and Clifford, which latter has a double bonnet perforated to admit air, and the Corset lamp.

Mercury Vapor Lamp. — The Hewitt mercury vapor lamp is the latest lamp of high merit on the market. It derives its light from the gas or vapor of mercury, in which the passage of an electric current causes a high state of incandescence. It is constructed of a glass tube having a metal sealing-in wire at each end, which wires lead the current to the electrodes, one or both of which are of mercury. The tubes are exhausted to a high degree on a vacuum pump, and sealed off, which prevents the escape of the vapor which fills the tube. The current consumption of this lamp is about .4 watt per spherical candle. The vapor being inclosed in a vacuum, there is absolutely no consumption of the light-giving element, and the lamp requires no trimming.

Comparative Summary of the Lamp and Reflector Industry.

	1880	1890	1900
Number of establishments...	74	93	156
Capital invested............	$1,873,625	$2,550,214	$6,375,474
Wage-earners	1,730	2,066	4,725
Wages paid..................	$742,423	$1,035,960	$2,076,980
Value of products..........	$3,357,829	$4,039,359	$8,341,374

Lacquered Work and Japanning.

How Lacquer is Obtained.—Lacquering is a very ancient art. The date of the discovery in Japan is given as 724 A. D., but it did not attain prominence until 1290 A. D. The raw material is obtained from the "Rhus vernicifera," or the lacquer tree. Japan produces annually 30,000 to 35,000 tubs of lacquer of 4 gallons each, collected in a manner similar to that prevailing in gathering the product of rubber trees. Woods to be lacquered are chosen according to the uses to which the lacquered articles will be put.

A Drawback.—The manufacture of lacquer ware would be greatly increased if some method could be found that would render the lacquer varnish perfectly clear and light-colored when so desired, without depriving it of its drying qualities, and also, if colors could be used outside of the limited number now in use. All pure lacquers are adulterated before they are permitted to be sold in the open market. Their manufacture in Japan is preserved as a profound secret.

What Lacquer Tools Are Made Of. — The brushes used are of finest material and workmanship. Rat's-hair brushes are used for tracing out patterns; hare's-hair for filling in patterns; deer-hair for making raised gold lacquer; human-hair for smoothing the lacquer; horse-hair for brushing; gold dust is scattered by using the quill from the wing of a swan, over one end of which a piece of silk is stretched. To polish crevices, a tooth of a fish is used, fastened on bamboo; the palette used is made of tortoise shell and is worn on the thumb.

Twelve Degrees of Fineness.—Twelve degrees of fineness of gold and silver dust are used. Shading is done by a mixture of pure gold dust and vermilion and silver. Various distinct shades are made by adding more or less color to gold and silver dust. No vegetable colors can be used, as they are chemically absorbed.

Tin Dust for Cheap Work.—Tin dust is used to make cheap work, and is sometimes burnt so as to be used as undercoats. In all, there are about twenty-two processes to be gone through before final finish on much of the work.

Raised Lacquer Patterns.—Raised lacquer patterns are made on plain wood; the whole surface is covered with tin-foil and stuck on with rice paste, but there are innumerable modifications for doing this work. Cheap work differs mainly from the finer work in the quality of dust used.

Lacquering on Metals.—Lacquering on metal, iron, copper, brass or silver, is done by coating with black lacquer over a charcoal fire, then rubbing smooth, which operation is repeated three or four times, and finally submitted to drying processes.

Best Work Very Costly.—Best lacquered wares are extremely costly. The Japanese are great connoisseurs of art, and prices are named which cause Europeans to hesitate before purchasing from the finer classes of workmanship so temptingly offered.

American Lacquering.—American lacquering is less artistic in design, and is executed with less regard to the requirements as they exist in Japan. A few general directions will enable American students of the art to do commendable work, if fair pains are taken. All wood to be japanned must be properly prepared with size, and some coarse material should be mixed with it to fill up and harden the grain of the wood, which must then be rubbed smooth with glass paper. Colors should be ground smooth in spirits of turpentine, to which a small quantity of turpentine and spirit varnish should be added; lay on carefully with a camel's-hair brush, and varnish with brown or white spirit varnish, according to the color desired.

The Colors Required.—The colors required for ordinary lacquer work are flake-white, red-lead, vermilion, lake, Prussian blue, patent yellow, orpiment, ochres, verditers, Van Dyke brown, umber, lampblack and siennas, raw and burnt; with these the student may match almost any color used in japanning.

Great Variety.—Lacquers are in great variety. English brass goods are covered with very pale lacquer; Continental lacquers generally have too much. The best and most rapid of bronzing liquids is nitro-muriate of platinum, called chemical bronze, known in the shops as terchloride of platinum. The art demands patience, natural aptitude, good taste and abundant leisure. It is one of those in-door employments which will ere long engage much attention.

Lard, Preparation of.

Kinds of Lard.—Lard is one of the most important products of the hog. Packers divide it into two kinds — leaf and steam — which is obtained from the surplus fat of the animal; the leaf is washed and sent to the rendering kettle, cut into strips three inches wide, which are again cut into squares about three inches long. The cutting has to be done with much care, for mangled leaf is detrimental to the production of a good article.

The Kettle.—The kettle is usually an open jacketed one with a space for steam between the two parts of the kettle. A heavy shaft suspended through the kettle horizontally has arms attached which pass close to the bottom. The shaft in revolving keeps the mass in constant motion. The kettle holds about ten tierces, and is kept constantly full, the steam being turned on in the jacketed space at a pressure of about 15 pounds and a temperature of about 222 degrees Fahr. The water taken on in washing the lard first rises as a vapor, and continues to vaporize as long as any water is left. After a time the surface begins to sink, showing that some of the leaf has melted, and the shaft and stirrers are started and the temperature is raised to about 250 degrees Fahr. Cut leaf is added from time to time, to keep the kettle full of lard to the brim when the rendering is completed. After about five hours the cooking is finished and the steam is turned off, a small amount of salt is thrown into the kettle, and after an hour of settling the lard is drawn off from the bottom through an opening over which there is a fine screen of wire cloth.

The Second Process.—From here the lard is run through an open tank, where it cools to a temperature of 160 degrees Fahr., when it is drawn into tin pails of about twenty quarts each, and from these, filled into packages of wood or tin and placed in a room where a blast of air of a temperature of about 40 to 45 degrees is blown over it. The rapid cooling causes a shrinkage of the surface and gives a crinkled effect that was formerly believed to be an indication of its purity. The color of leaf lard is creamy. Nearly everything to-day enters into leaf lard from leaf to belly trimmings. Much leaf lard is made into neutral lard free from animal smell and taste.

Steam Lard.—Steam stock for making steam lard comes from all sources and every grade of hog product from the feet trimmings or feet themselves to the skull or head-bone. The rendering is done in tight iron cylinders from 30 to 72 inches in diameter and from 6 to 16 feet deep, generally suspended through one floor with a discharge at the bottom of about 12 inches in diameter and an inlet opening at the top of about 16 inches in diameter. Both these openings are covered. The pressure of steam used varies. After rendering is completed and the steam pressure removed, the tank is allowed to settle. The refuse, such as bones and flesh tissue, sinks to the bottom of the tank and is used in making fertilizers.

Refining Process.—The lard rises to the surface and is drawn off into large steam jacketed kettles holding 20 to 30 tierces each. These kettles are then heated to above the boiling point of water. This is the refining process, and is continued until the water in the lard ceases to rise as vapor from the kettle. As soon as the water is evaporated the lard settles and is pumped into a large cooler before it is prepared for shipment. The failure to remove all the water in this process of refining is the cause of rancid or spoiled lard.

The number of hogs slaughtered in 1900 was 30,654,333, valued at $278,736,961. The gross weight on hoof was 6,684,658,916 pounds; dressed weight, 5,209,480,364 pounds; refined lard, 891,438,417 pounds; value, $52,620,348; neutral lard, 129,345,282 pounds; value, $8,588,350.

Comparative Statement of the Refined Lard Industry.

	1880	1890	1900
Number of establishments..	26	17	19
Capital invested............	$2,513,066	$3,898,910	$1,335,259
Wage earners................	1,181	888	499
Wages paid..................	$546.258	$460,102	$237,930
Value of product............	$23,195,702	$15,474,848	$8,630,901

Leather, The Making of.

Tanning Sole Leather.—The sole leather tanners can no more make a glove leather than a blacksmith can make a watch, because of the different methods and materials required to tan different kinds of skins. The skins used range from the common raw hide to the delicate lamb skin for ladies' gloves. In preparing the hides for tannage they are first brought to a natural state by soaking in water. The salt is removed and the hides soaked until they are soft and pliable and free from blood. After this the loosening of hair begins. Green hides are limed and dry hides are sweated. The process of loosening the hair by means of lime consists in subjecting the hide to the action of a milk-of-lime from three to six days. Sulphite of soda is used to assist the lime. It forms a caustic soda and sulphide of calcium, which act as a solvent for the hair.

Sweating of Dry Hides.—Dry hides are sweated in a closed room at a temperature of 70 degrees. This is a very delicate process, as the incipient decomposition which sets in must be watched closely. Sometimes the hides are put in a milk-of-lime to arrest the reaction which sets in at the proper time. The mechanical process is performed both by hands and by machines. For ordinary commercial purposes leather is divided into three general classes—hemlock, oak and union. Hemlock is made from dry and green hides, while the other two are made from green.

Oak, Hemlock and Union Leathers.—Oak bark gives a deposit on the leather called "bloom;" oak leather is known as scoured or unscoured, depending on whether the "bloom" is removed or not. Hemlock comes in two varieties, acid and non-acid. In the "acid" kind sulphuric acid is used to swell the hides, thus producing a firmer leather. Acid is of two kinds—"limed acid," made from green hides, and "sweat acid," made from dry hides. These leathers are generally put through the same process. All varieties, when taken out of the vats, are washed or scoured, oiled and dried, then dampened, rolled and redried, ready for sale.

Cost.—Sole leather is sold by weight; from 60 to 80 pounds of leather is obtained from 100 pounds of green hides, or 150 to 185 pounds from 100 pounds of dry hides. The object of the tanner is to swell the hide and satisfy its chemical affinity for tannin in weak liquors; after the chemical affinity is satisfied and the hide plumped, the secondary operation of weight-making commences. The concentration of liquors is increased, and as much tannin is put in solution in the leather as the plumpness and selective action of the hide will take.

Element of Time in Tanning.—The element of time is essential for the proper absorption of tannin as a dye in sufficient quantities to give the maximum weight. The tannin does not change materially, and is almost immediately recovered from the solutions. Various processes have been brought forward to reduce the time necessary for the proper chemical action, but their merit is a matter of question. The application of the electric current is receiving considerable attention. The Durio process consists in agitating the hides in a wheel in concentrated liquors.

Glossing Sole Leather.—Sole leather is finished by glossing with brass rolls. The leather is partially dried in a dark dry-room. The principle upon which the sole leather rollers work was discovered in 1836, and this general, but latterly improved process, continues in use.

Chrome Tannage.—There are two processes of chrome tannage commercially recognized — the "one" and "two" bath methods. The former is in principle a neutral solution of chromic oxide; the "two-bath" process consists of bichromate of potash, chromic or muriatic acid, which is followed by a reduction bath in hyposulphite of sodium or other modified combination with hydrosulphites.

Chrome-tanned Leathers. — Chrome-tanned leathers do not possess the coloring properties of bark-tanned leathers. At first only sheep and goat skins were tanned by the so-called chrome process. At present the process is used on calf, kid and cowhide leathers. Attempts have been made to use it on sole leather without success. Leather tanned by this process is exceedingly soft and pliable and of close texture. The "chrome" process is very rapid, and the time required for converting into leather after the preliminary process is but a few hours.

Tanning of Goat and Sheep Skins.—Goat and sheep skins are received from all over the world. Those from Calcutta and Madras are known as "India tans." The skins are saturated with a solution of logwood liquor, then submerged in another liquor, then colored with an emulsion of oil, water and soap known as "fat liquor." They are then stretched, dried and subjected to superheated air and thoroughly softened or "staked"—i. e., stretched by hand or machine—which makes them ready for the seasoning process. The seasoning process consists in treating the grain surface with a light dressing; then follows glazing. They are usually glazed twice, and somtimes three times, the workmen using a glass of cylindrical shape. The friction produces the gloss. This was the old hand process, which has been supplanted by machines making from 150 to 200 revolutions per minute, in which the pressure is regulated by means of springs. The friction which produces the gloss is made by means of a glass cylinder.

Currying and Finishing.—The process of currying consists of softening and equalizing the leather, dressing, polishing and slicking it; the object of the various manipulations being to make the leather pliable and elastic.

Commercial Terms.—Hides and skins tanned by vegetable processes are known as "rough," "unwrought" or "crust." The tanned stock is often softened by being placed in a revolving tumbler or wash wheel; sometimes it is done in stationary tubs or vats. The heavier hides are split into two or more pieces, the hair side being made into grain leather and the flesh side into splits. When split more than once, the pieces taken between the grain and flesh are termed "middle splits." After "splitting" the stock is sometimes retanned in mild liquors. Smoothed finished leather is termed "glove grain;" pebbled leather is finished on rolls of steel or metal which have been cut or engraved to make an impression to meet the requirements of trade. "Shaving" is another term used, and consists in removing fleshy particles, and this is also done by mechanical appliances. "Stuffing" is the process of filling the pores of leather with grease to keep it soft. The compound used consists of tallow, stearine, degras and brown grease in varying proportions. The leather is then smoothed, stretched, slicked and seasoned to receive the final blacking or colors.

Patent and Enameled Leathers.—In the preparation of enameled leather the foundation of a coat of lamp-black mixed with linseed oil is laid on the flesh side of the skin. It is put on warm and spread on evenly. The skins are then hung up to dry, and submitted to various more or less secret processes.

Grain Upper Leathers.—Upper leather may be made from the green, salted or dry hides. The soaking may take from three to six days. If side leather is to be made, the hides are split from head to tail on the line of the back bone. When soaked, each hide is laid over a cylindrical table or beam, and the flesh and meat removed by machines. The details of the process are too intricate to admit of a full description. When the "stuffing" process is reached, about 80 sides are stuffed at once, in from 40 to 60 minutes. The leather is then made smooth by being set out with stone and steel hand tools, called "slickers," after which it is hung up to dry from two to four days. When dry it is taken down and the grain is prepared for blacking. A black is produced over the grain by two applications—first, by logwood water; second, by copperas water—again hung up, and when dry is ready to finish.

Waxed Splits.—The splits, when tanned, are dried and stuffed in the same manner as the grain; after being set up they are whitened, trimmed, blacked and slickered, then treated to a coating of flour paste, set or glassed again, and then given a finishing coat. Waxed upper leathers differ from grain upper leathers in that, like wax splits, they are finished on the opposite or flesh side; but they are similarly used as a substitute for calf skin in heavy and low-grade shoes.

In 1900 there were 313 leather goods factories, an increase from 60 in 1880, employing 6,253 workmen and producing goods worth $11,717,401.

Comparative Summary of the Leather Industry, Tanned, Curried and Finished.

	1880	1890	1900
No. of establishments......	5,628	1,788	1,306
Capital invested............	$73,383,911	$98,088,698	$173,977,421
Wage-earners..............	40,282	42,392	52,109
Wages paid................	$16,503,828	$21,249,989	$22,591,091
Value of products..........	$200,264,944	$172,136,092	$204,038,127

Leathers, Patent and Enameled.

Foundation Process.—For a long time patent and enameled leathers were chiefly made in Germany and France. Latterly they have been successfully made on an extensive scale in the United States. The foundation of enameled leather is made with a coat of lamp-black mixed with linseed oil, laid on the flesh side of the skins. After this process the skins are hung up for three or four days and dried. The surface is smoothed either by machine or hand, with the assistance of ground pumice stone. This is continued until the first coat is smoothed down, nothing but the virtual root of it remaining.

Further Process.—This process is repeated with four, five or six coats, and the skins are then blackened with a black fluid mixed with turpentine and hung up to dry again. After a month or longer the leather is given a brush coat of varnish. A three-days' baking is then given in a rising temperature. It is next placed in the sun to harden the varnish. The sun and air oxidize the varnish, after which the stock is finished.

Points of Success.—All patent leather is varnished on the grain or hair side. Chrome-tanned leather is very "stretchy" and flexible, just the reverse of the bark-tanned. Success depends upon making the application on the surface of the grain absolutely adhesive, so that the varnish will not peel, and it must be as thin as possible, in order to give it the same proportion of flexibility as the grain and fibre possess.

Leather Trade, Terms and Definitions in.

Leather Terms.—Belting is made of bark-tanned cowhides. Buff is split side leather. Cabaretta is tanned sheepskin of superior finish. Calfskin is made of neat cattle of all kinds from Texas long-horns to the sacred cattle of India, weighing up to 15 pounds. Coltskin is the skin of colts, but split horsehide often passes for it. Composition is made of tannery and factory scraps mixed with paste or cement. Cordovan is made either from goatskins or horsehide, but this term is applied commercially to split horsehide. Cowhide refers to hides of cattle heavier than kips, which run up to 25 pounds' weight. Dongola is heavy, plump goatskin tanned with a semi-bright finish. Enamel is leather that has a shiny finish on the grain side, to distinguish it from patent leather, which is usually finished on the flesh side or the surface of a split. Glove grain is light, soft-finished split leather. Harness leather is made from sides heavier than kips. Hides are skins of cattle above 25 pounds in weight. By skins is meant the covering of goats, calves, sheep and other animals.

Much of the "kangaroo" sold, if it could speak, would deny its alleged paternity. There is kangaroo leather, but much of it derives its claims to the name in the tanning only. Kid is made from the skin of grown-up goats, that of the young kid being used for gloves. One quality that distinguishes goat leather, the kid of shoemaking, is that the fibres of the skin are interlaced and interlocked in all directions. Instead of ripping straight through like a piece of cloth, or splitting apart in layers, as sheepskin will do when made into leather, the kid holds together firmly in all directions. No two skins come through the tanning process alike.

Other Leather Terms.—Matt is a term applied to the dull finish given kid, as distinguished from glaze. Morocco is sumac-tanned goatskin, red in color, and used for bookbinding, and the term is also applied to its imitation. Monkey-skin is mostly an imitation of our reputed progenitors. "Pancake" is made from leather scraps shived thin and cemented under heavy pressure. Patent leather is japanned or varnished leather, and is not patented. Calfskin is shaved on the flesh side to uniform thickness, and successive coats of liquid black varnish are applied, the first coats being dried and rubbed down, so as to work the liquid thoroughly through the fibre. The last coat is applied with a brush. The varnish used is made of vegetable gums and oils. Kid and goatskin are also used as the basis of this leather.

Satin calf is a grain-split leather stuffed with oil and smooth-finished. Seal grain is a flesh-split with an artificial grain, or has an indented tracery. Sheepskin is used largely for linings. Sole leather is made from heavier hides of cattle and tanned with oak or hemlock bark, with other vegetable extracts. Splits are split leathers; the hide, after being cut in two down the back, is run through a machine between rollers, and impinging upon a sharp knife edge splits it into two or more sheets.

How to Tan. — Tanning is the treatment of skins and hides with tannic acid or some other astringent substance. The process, in a small nutshell, consists of soaking, removal of hair, scraping, second soaking, during which time the hides, placed in vats, are worked back and forth; next comes dressing, then stuffing with oil or grease; they are then dyed, blacked and polished. Tanning is done by soaking hides in a solution of salt and alum, and is used on skins, rugs and furs. Velours—French for velvet—is chrome-tanned leather. Vici is a proprietary name for chrome-tanned kid, a popular and most valuable leather.

Lime and Cement Manufacture.

Uses of Lime and Cement.—The rapid development of engineering science in connection with railroad and general building construction has contributed a powerful incentive to the industry of lime and cement manufacture. As long as buildings were of comparatively small size, the use of lime and cement was unimportant. But with the enormous activity in railroad and bridge construction and the building of mills, factories, shops and warehouses of large size, requiring a maximum of stability and endurance, the demands for lime and cement expanded prodigiously. Cement became an elemental factor in large construction, taking the place of brick, stone, and, to a degree, lumber, and becoming an important associate in iron and steel construction.

Function of Cement.—Engineers discovered in cement a most valuable assistant to impart durability and enable structures in which it was used to resist or endure strains. Its cheap production rendered it a valuable material in lighter construction, simplifying operations and adding much to the substantial features so imperative in the eyes of builders. It serves for fireproofing purposes as well, and, because of its easy handling and low cost, attained an importance which continued use emphasizes more strongly. The industry is being centralized, and plants of extraordinary capacity are being erected contiguous to abundant sources of supply.

Cement includes solder, gums, putty, mucilage, glue, plaster of Paris, limes and hydraulic cements. Hydraulic lime and hydraulic cement are the most important commercially.

Lime.—Lime is made by burning limestone in kilns until carbonic acid is driven off. Slacking of lime is due to its rapid absorption of water. The process of hardening lime mortar consists in the gradual formation of carbonate of lime through the absorption of carbonic acid from the air.

Hydraulic Lime. — This lime is obtained from limestone having silica and alumina sufficient to make it harden under water.

Hydraulic Cement. — Hydraulic cements are classified as natural cements, Portland cements and puzzolanic cements. Natural cement is made out of limestone at low temperature without pulverization. It is well known in Europe as Roman cement. The process of manufacture consists in quarrying, breaking into lumps, calcining with coal in kilns, crushing and grinding the clinker.

Portland Cement.—This cement is made of material containing silica, alumina and lime, and calcining to incipient vitrification. In this country it is produced in a rotary kiln, where the dry powder or the wet paste is run into the kiln without previous brick-making or drying. After incipient vitrification is reached, the clinker is crushed and ground to impalpable powder, and then "cured." Fine grinding is essential to good cement, and the best brands will pass through a sieve having 10,000 meshes per square inch.

Puzzolana.—This cement, made of a combination of silica and alumina, hardens under water.

Production.—The production of cement in the United States is in the neighborhood of 25,000,000 barrels per annum. Numerous cements are obtained from animal, vegetable and mineral substances, and are used for a great variety of purposes, according to their demonstrated fitness.

For the year 1903 the consumption of Portland cement may be estimated at over 21,000,000 barrels.

Growth of the Consumption of Cement in the United States.

Year.	Pounds per capita.
1850	6.46
1860	10.49
1870	12.77
1880	13.04
1890	33.93
1900	91.82
1902	119.00 (estimated).

Comparative Summary of the Lime and Cement Industry.

	1880	1890	1900
Number of establishments	615	873	1,000
Capital invested	$6,332,338	$18,752,396	$48,833,730
Wage-earners	5,669	13,043	19,107
Wages paid	$1,579,313	$1,944,313	$7,749,815
Value of products	$5,772,318	$15,741,801	$28,689,135

Linens, Making of.

Restricted Cultivation of Flax.—For various reasons the linen industry has never obtained a very firm foothold in the United States. In colonial times efforts were made to promote the growth of flax and to introduce the spinning and weaving of the fibre. It was the policy of the mother country to repress manufacture in the colonies, but, notwithstanding this opposition, the production of linen goods made some headway. The cultivation of flax was undertaken and continued on a small scale, and the spinning-wheel and the hand loom were used as the only available machines for working it into fabrics for various purposes.

The Cotton Gin Headed Off Flax.—The cultivation of flax would no doubt have been entered upon vigorously by the colonists and their followers, but the invention of the cotton gin by Eli Whitney, patented in 1793, placed in their hands a cheaper fibre than flax, more tractable and requiring less care in separation. It was also more easily spun and woven, and was found superior for many purposes and inferior for few. It therefore has taken the field, as it were. Linen is indispensable for fine fabrics, for the dining-table, for thread and twine where great strength is required, and for the best quality of toweling.

Need of Flax.—There has been a gradual increase in flax cultivation, notwithstanding all the difficulties encountered. An urgent demand for linen has of late years arisen, which has stimulated production. A few industries require a great deal of cotton thread, and the market for towels and toweling is practically unlimited. The manufacture of linen toweling has developed into a very important industry.

Linen Market.—There is a large demand for linen carpet yarns. The immense shoe-manufacturing industry requires a great deal of linen thread. Several large cotton manufacturers are creeping into the linen industry, and are using over 1,500,000 pounds of linen yarn annually.

Statistics.—The number of linen goods factories increased from 3 in 1890 to 18 in 1900; capital invested, from $908,589 to $5,688,999; wage earners, from 574 to 3,283, of which about one-half have been women. Wages paid increased during that decade from $167,134 to $1,036,839, and value of products from $547,273 to $4,368,159.

Liquor and Wine Making.

Liquors and Wines in Early Times.—Liquors and wines were produced ages before the dawn of history. Nature itself might be compared to a vast distillery. The vine and its fruit are supposed to be almost as ancient as the habitable earth itself. The artificial and temporary stimulus which is imparted by liquors doubtless led to devices for production, and from earliest recorded ages history affords evidences of almost universal use among people. It was long ages before vines producing liquors were domesticated, and many ages more before scientific methods were applied to the production. The nomadic nature of early societies rendered the systematic production of wines or liquors impossible; but as people began to congregate, history notes the development of more or less crude appliances for production, and also notes the rapid progress of use.

Wines in Grecian and Roman Times.—The wines of Greece and Rome were highly flavored with spices and aromatic herbs, and in these countries viniculture obtained its highest development. The methods of early manufacture are entertaining and instructive, especially because of absence of economic appliances. The early navigators who reached American shores, in all their writings and reports spoke of the abundance and variety of grapes along the coasts. American colonists mostly came from countries in Europe where the manufacture of wine had been an important industry, and they soon sought to supply their actual or supposed needs. The production early developed sufficiently to allow of exports of considerable quantities to the West Indies and even to Europe.

First Wine Made in America.—The first wine manufactured in the United States was made in Florida, about 1565. In 1610 it was made in the Jamestown colony, Virginia. The cultivation of the vine was greatly stimulated ten years later. The French colonists who spread over the West developed wine-making to a wonderful degree. As far back as 1814 there were 14,191 distilleries in the United States, which produced 22,977,167 gallons of spirits from fruits and grains. There were 132 breweries, which produced in that year 182,690 barrels of malt liquor besides large quantities of malt liquors. A large number of wineries sprang into existence, number not given, which produced wines from currants and grapes of remarkable richness and purity.

First Commercial Success.—The first really successful attempt at commercial wine making was made by Nicholas Longworth, of Cincinnati, Ohio. Mr. Longworth spent forty years in trying to make American wine manufacture a success, and practically laid the foundation of the industry. The total value of the wine product of the United States in 1860 was only $400,791. The increase in production at first was gradual, but with the development of California it grew to large proportions rapidly.

California Wine.—It was in the State of California that the greatest impetus was imparted to wine making. The vine was introduced on the Pacific coast by Spain, by way of Mexico, in 1771. The San Gabriel Catholic Mission started the first vineyard. The industry expanded through the activity and industry of the priests, who employed native Indians as workmen. The "Mission" grape soon became well known, and the production soon averaged from 700 to 1,000 gallons of wine to the acre. In 1845, when Spanish power fell, the missions were abolished and confiscated, and the wineries and vineyards fell into ruins.

Revival of the Industry.—The Legislature of California took steps, in 1861, to establish wine making upon a permanent basis. One hundred thousand vines, embracing 1,400 varieties, were purchased in Europe and distributed throughout the State, and thus laid the foundation of the industry.

Kinds of Wine.—Wines are divided into sweet and sour, according to color red and white, and chemically into "still wines" and "champagnes." In fermentation the sugar is converted into alcohol. For sweet wines grapes rich in sugar are chosen, and before enough of the sugar is fermented to convert the juice into a dry wine, some form of alcohol is added to give the requisite alcoholic strength and arrest fermentation. Hence it is termed "fortified," because further fermentation is arrested.

Red Wines.—Red wines are made from grapes with highly colored skins, which are fermented with the juice, and from which the alcohol formed by the fermentation of the sugar absorbs the coloring matter.

Champagne.—Champagne is an effervescent wine named from the place in France where it was first manufactured. Effervescence is due to the formation of carbonic acid gas retained under pressure. The manufacture of champagne entails great labor, time and skill, and about three years' time is necessary to perfect it.

Sweet and Dry Wines.—Sweet and dry wines shade off into several types, and may be red and white, still or sparkling. They are known as sauternes, Rhine wines, Burgundies, sherries, Madeiras and ports; claret is a name given to dry reds or those of a general Bordeaux type. Sauternes and Rhine wines are dry, usually white, but sometimes red. Burgundies are dry, red or white, still or sparkling. Sherries are "fortified" wines, and are termed sweet or dry, and are white or tinted. Madeiras are still wines, sweet, and usually red.

Brandy.—Brandy is a natural by-product of wine manufacture, being distilled from cheese, wash or piquetta. Fifteen gallons of cheese, 10 to 12½ gallons of wash or 7 gallons of piquette will produce a gallon of brandy. Certain grades of wine are sometimes distilled into brandy. Five gallons of sweet, or 7 gallons of sour wine will, in distillation, produce 1 gallon of brandy.

Alcohol.—Alcohol is a natural product derived from sugar in the process of alcoholic fermentation. Wine is the simplest, and its manufacture the least complex of all alcoholic liquors, as it consists of fruit juices whose saccharine matter is converted into alcohol on exposure to the air.

Malt Liquors. — The manufacture of malt liquors is more complex, as it involves the preliminary process of malting, which converts the grains of starch into sugar, and which in turn is converted into alcohol by fermentation. Hops are an essential article in the brewing industry. The total amount of the world's hop production is estimated at 1,760,000 hundredweight. The total consumption of hops by brewers throughout the world is equal to this amount. The American product for 1903 was 462,000 hundredweight; England, 418,000 hundredweight; Germany, 533,500 hundredweight. The chief center of American production is in Oregon where the art of cultivation has been developed in its highest degree and in most profitable manner.

Equipment for Wine Making.—Equipment for wine making consists for the most part of tanks, cisterns, cooperage, cellarage, machinery for stemming and crushing grapes, pumps and hose for moving the wine at different stages in the process of maturing. In California machines capable of stemming and crushing 300 tons of grapes daily are in use, and tanks or cisterns with a capacity of 25,000 to 30,000 gallons are common. The largest cistern in that State was constructed by a Swiss-Italian colony, and holds 500,000 gallons.

Whiskey. — Whiskey is distilled from corn, wheat, rye, barley, and sometimes from sugar, molasses and potatoes. The process of manufacture has remained practically stationary, except as to appliances for conducting the various operations from the grain to the matured product. The industry is conducted in various sections, much whiskey being made in Western Pennsylvania and Kentucky, in which latter State the name of "Bourbon" is applied to it. The industry is subject to comprehensive and rigidly applied Governmental regulation, and a considerable portion of the Governmental revenues are collected from its manufacturers, which are indirectly paid by the consumers. The product of distillation of corn forms an important part of the total. Rye whiskey is in greatest favor among users, though a considerable portion is made from other grains.

Gin is a strong alcoholic liquor distilled from rye and barley and flavored with juniper berries. Common gin is usually flavored with turpentine.

Rum is distilled from cane juice or from the screenings of the boiled juice, or from treacle or molasses, or from the lees of former distillation. It is largely made in the West Indies. It is colorless as it issues from the still, but to suit the taste of consumers the distiller colors it. Its strength as imported is usually about 20 per cent. over proof, but before passing into the hands of the consumers it is reduced with water. Rum sold below 35 per cent. under proof is considered to be adulterated with water unless the purchaser is informed of its exact strength when purchased. Much of the rum sold in this country is merely plain spirit colored with burnt sugar and flavored with rum flavoring.

Cordials.—Cordials are formed of weak spirit aromatized and sweetened. The materials employed in their preparation are rain or distilled water, white sugar, clean, flavorless spirit and flavoring ingredients. The apparatus used is the same as for wine making, and a copper still furnished with a pewter head and a pewter worm or condenser when distillation is pursued. French liqueurists distinguish their cordials as ''eaux'' and "extraits," which, though sweetened, are entirely devoid of viscidity, and "baumes, "crêmes" and "huiles," which contain sufficient sugar to impart to them a syrupy consistence. The art of the liquorist can only be attained by long practice.

The average value of champagne in 1900 was $3.93 per gallon, and of still wine 24 cents per gallon. In Ohio the quantity of wine produced from each ton of grapes was 155 gallons; New York, 151; California, 119. The United States ranks fourteenth in wine production in the world.

Comparative Summary of Distilled Liquors.

	1880	1890	1900
Number of establishments . .	844	440	967
Capital invested	$24,247,595	$31,006,176	$32,551,604
Wage-earners	6,502	4,762	3,722
Wages paid	$2,663,967	$2,246 064	$1,733,218
Value of products	$41,063,663	$104,197,869	$96,798,443

Comparative Summary of the Malt Liquor Industry.

	1880	1890	1900
Number of establishments . .	2,191	1,248	1,509
Capital invested.	$91,208,224	$232,471,290	$415,284,468
Wage earners.	26,220	30,257	39,532
Wages paid.	$12,198,053	$20,713,383	$25,826,211
Value of products.	$101,058,385	$182,731,622	$237,269,713

Comparative Summary of the Wine Industry.

	1880	1890	1900
Number of establishments . .	117	236	359
Capital invested.	$2,581,910	$5,792,783	$9,838,015
Wage-earners	967	1,048	1.163
Wages paid	$216,559	$299,453	$446,055
Value of products.	$2,169,193	$2,846,148	$6,547,310

Distilled Liquors.—As a producer of distilled liquors, Illinois leads with a production in 1890 of 32,508,435 gallons of spirits. Kentucky followed with 21,709,873. Indiana, Ohio, Pennsylvania followed in the order named. In Illinois the industry is largely centered at Peoria, while in Kentucky it is scattered.

The total quantity of spirits distilled in 1900 in the United States was 109,245,187 gallons, in which were used 24,258,500 bushels of grain, 1,339,606 gallons wine and 2,962,691 gallons of molasses and fruit. Generally speaking, grain is used in the manufacture of gin, whisky, alcohol and cologne spirits; fruit and wine in the manufacture of brandy, and molasses in the distillation of rum. Out of each bushel of grain used, 4.16 gallons of gin, whisky, alcohol or cologne spirits were produced. Wheat is little used because of its greater cost, while corn is largely used because of its cheapness. Of the total amount of grain consumed, 68.2 was corn.

The distillation of alcohol and pure neutral or cologne spirits is largely confined to Illinois and Indiana, that of Bourbon to Kentucky and that of rye whisky to Pennsylvania and Maryland.

In 1870, 72,560,929 gallons of distilled spirits were manufactured; in 1880, 91,378,417 gallons; in 1890, 111,101,738 gallons, and in 1900, 109,245,187 gallons.

In 1890 the amount of distilled spirits consumed in the arts was 10,976,842. No record was made for 1900. The actual consumption for 1900 was about 91,000,000 gallons.

The total exports are under 2,000,000 gallons, of which about one-fourth goes to Germany.

Locomotive and Stationary Engines, Principles of Construction and Running, The.

Importance of the Locomotive.—To tell the story of the greatest machine known to modern times, the locomotive, is a task beyond the province of anyone. The locomotive of to-day represents a thousand inventions and improvements. No single machine has attracted so much inventive talent, steady and concentrated mechanical ingenuity as this wonderful product of the past century. The only limit of its growth is the size and capacity of the boiler. The more essential features are the boiler, steam chest, fire-box and cylinders. The remaining features might be termed secondary.

Evolution of the Locomotive.—Types of engines are classified according to the arrangements of the wheel bases. The evolution of the locomotive from the "Rocket" to the latest Atlantic type has been a record of brilliant mechanical progress. The eight-wheel locomotive was for many years the standard used on all roads. Forney's locomotive was a modification of this and the Columbia was the predecessor of the Atlantic type. The Mogul, which originally was its shop nickname, has three pairs of driving wheels. The ten-wheeled locomotive possesses an increased adhesion and its boiler can be made larger. The Consolidation, exclusively for freight service, has ten wheels, of which four pairs are drivers. The Decapod is carried on ten wheels and is used on heavy grades. The Mastodon is exclusively used for heavy freight service.

Railway Signals.—The following signals have been adopted by the American Railway Association: Red: danger, stop; green: caution, go slowly; white: safety, go ahead; green and white: stop train at flag-station for passengers or freight; blue: used by car inspectors and repairers, cars must not be moved; explosion of one torpedo: stop immediately; two torpedoes: reduce speed; a fusee is an extra danger signal used at night in case of accident or emergency.

Day and Night Signals.—Train signals by day are two green flags; by night, two green lights, one on each side of the rear of the train as markers. Yard engines display two green lights instead of red, except when provided by a headlight, front and rear. Two green flags by day and night, and in addition two green lights by night, denote the train is followed by another running on the same schedule and entitled to the same time-table rights. Whistle signals convey a good deal of information. One long whistle signifies approach to station, railroad crossings and junction; short blast, apply brakes; two long blasts, throw off the brakes; two short blasts is an answer to any signal except "train parted." Three long blasts is a signal that the train has parted; three short blasts, when the train is standing, means that the train will "back." Four long blasts call in a flagman from east or north; four short blasts is the engineer's call for signals from switch-tenders, watchmen, trainmen and others; five short blasts is a signal to flagman to protect rear of train. One long and two short blasts is a signal to be given by trains on single track when displaying signals for a following train to call the attention of trains of the same or inferior class. Two long, followed by two short blasts, is the signal for approaching grade crossings. A succession of short blasts is an alarm for persons or cattle, and calls the attention of trainmen to danger ahead. One tap of the signal bell when the train is standing is the signal to start; two taps when running is the signal to stop at once. Two taps, when the train is standing, calls the flagman; three taps when the train is running is signal to stop at next station; three taps when the train is standing is the signal to back; four taps when the train is running is the signal to reduce speed.

Qualifications of Engineers.—The engineer must know the road as a pilot knows the river. He must know every grade, curve, crossing, station approach, bridge, signal and whistle or bell post, and must know them on dark or stormy nights as well as in daylight. He must always know where he is, where every water-tank is located and the qualities of water at different tanks. He must particularly know all grades, what his engine can haul, how his engine must be handled on them and how they must be approached. He must, above all, understand how to handle the air brake, and have a memory capable of holding and applying a vast number of rules and regulations.

New Features.—The most marked features in the development of the locomotive may be summarized as follows: increase in size and weight, increased tractive power and speed, larger boilers with thicker shells, larger fire-boxes and increased grate area to produce higher steam pressure and greater steam generating capacity, economy in use of steam by compounding and the substitution of steel castings for wrought-iron and iron castings for several important parts.

Weight of Locomotives.—In 1890 the average weight of locomotives was 92,000 pounds for the engine alone, exclusive of the tender; in 1900, 129,000 pounds, an increase of 40.2 per cent. The average weight of locomotives, including tender, was 158,534 pounds, or 79.3 short tons. The largest engine built up to 1900 weighed 133 tons, or, with the tender, nearly 190 tons.

Pressure on Boilers.—In 1870, 130 pounds was a fair average of pressure in boilers; in 1890, 160 pounds; in 1900, 225 pounds were more frequently used to meet the requirements of heavier traffic and greater speed. Heavier steel plates were used to meet this increased pressure. Ten years ago the average thickness was one-half to nine-sixteenth-inch plate, but at present seven-eighth-inch plate is frequently used. There has been a marked increase in length and diameter of boilers.

Fire-Box.—To provide heat for these increasing dimensions and steam pressure requirements the fire-box has been enlarged and additional grate surface has been provided. For a long time the space between the frames was sufficient, but it became necessary to extend the fire-box to occupy all the space between the tires of the driving wheels.

A New Type.—When this space was all used, and as much additional length given as was found possible, a radical departure was entered upon, resulting in the evolution of a new and distinct type of locomotive in which the driving wheels are moved forward and placed under the cylindrical portion of the boiler; the fire-box being supported by a single pair of wheels of smaller diameter placed underneath so as to permit an increase of its width.

Wootten Fire-Box.—The Wootten fire-box is raised over the top of the driving wheels and extends beyond them on each side, thus affording a very large grate surface and reducing the height of the fire-box. This fire-box has been modified, or rather departed from, in a box which is placed wholly behind the driving wheels, overhanging a pair of low trailing wheels instead of drivers.

The Cylindrical Corrugated Fire-Box.—This involves a radical change in boiler construction and is taken from marine boilers. Its advantages are: the cylindrical form of boiler throughout, elimination of flat surfaces and avoidance of the troublesome stay-bolts.

Grate Areas.—The grate area of fire-boxes between the frames is about 27 square feet. By extension between the driving wheel the area is 35 square feet. In the Wootten type the area is 80 square feet, although 44 square feet is mostly used.

The Compounding Principle.—Out of 2,831 steam locomotives built in 1900, 329 were compounded. Their points of utility are these: the cross-compound has one high pressure and one low pressure; the four-cylinder compound has the high-pressure cylinders either above or below the low-pressure cylinders; the four-cylinder balanced compound has its high-pressure and low-pressure cylinders located side by side instead of one above the other, their axis being parallel; the four-cylinder tandem compound has a high-pressure and a low-pressure cylinder on each side of the engine, the two cylinders having the same axis and both pistons being attached to the same rod. There is a still later modification which is not in general use as yet.

Perfect Balance.—The most perfect balance is secured in this form of construction, permitting a maximum load on the drivers without injury to the track. The question of ultimate economy between single expansion and compound engines is still under discussion.

Minor Improvements.—There is a larger use of steel castings for cast-iron centers. Until recently locomotive frames have been forged from iron or steel, but experience has demonstrated that steel castings can be depended upon with perfect safety, both for driving-wheel centers and for frames.

Valve Construction.—The introduction of the compound principle has necessitated a radical change in valve construction. In locomotives with cylinders in parallel pairs a cylindrical piston valve is substituted for the slide valve used on simple locomotives.

Oil-Burning Locomotives.—For oil-burning locomotives only slight alterations in the arrangement of brickwork in the fire-box are necessary, including burners which throw into the fire-box a spray of steam and vaporized oil, by which an intense heat is generated.

Firing Engines.—Engines have grown to such immense size that it taxes the strength of the firemen to feed coal. Mechanical stoking is contemplated should larger engines be constructed.

The export of locomotives, beginning with 1890, has been as follows: 1890, 161; 1891, 275; 1892, 197; 1893, 195; 1894, 142; 1895, 252; 1896, 261; 1897, 338; 1898, 468; 1899, 517; 1900, 525.

American Methods of Locomotive Making.—The excellence and comparative cheapness of American locomotives is due to the efficiency of tools and processes and to the elimination of hand labor to a considerable extent. The boiler is built in two sections by power riveting. Traveling cranes handle the sheets, multiple-spindle drilling machines bore many holes simultaneously and through several sheets at the same time if desired. The flanging of dome rings, furnace door flanges, tube sheets, etc., is done in one heat at a single operation by hydraulic flanging presses. The boring and facing of cylinders is done by the same machine. Coupling and coupling rods are clamped together and melted in a lump. Several frames are similarly planed and slotted. Multiple work is also applied to making fittings and many minor parts.

Assembling of Parts.—Practically every part of an engine is finished and fitted, and some parts are even painted, before transferred to the erecting floor. The work is done by gangs, each doing one specified part. Locomotives have been constructed in eight days from the time the order was received.

Laws of Train Operation.—Among the rules adopted by the American Railway Association in substance are these: All trains are classified according to priority of right of track. Trains of an inferior class must take the siding. Five minutes must intervene between departure of passenger trains, and freight trains must keep five minutes apart unless some form of block signal is used. Trains must keep inside schedule time. In cases of detention, the flagman must go back and the fireman or front brakeman must go forward. Regular trains 12 hours late lose their schedule rights. Conductors and engineers are held equally responsible for violation of rules.

Principal Builders.—The largest companies building locomotives are the American Locomotive Company and the Baldwin Works, the latter company located at Philadelphia, Pa., and having a weekly capacity of from forty to forty-nine engines. The American Locomotive Company is a combination of other leading works. A fair estimate of the average daily locomotive building capacity is fourteen per day, which capacity is being expanded to meet the demand due to the enormous growth of traffic.

Remarkable Improvements.—The demands for greater speed and greater power are leading to remarkable improvements in construction, one of which is the use of nickel in the bearing parts. The American conception of locomotive building with the interconvertibility of parts has made a strong and abiding impression on the railroad engineers of the world.

The leap from the Watt to the Corliss covers the most important period in the world's history. The development from the stationary engine to the mammoth engine of to-day was made step by step, starting with the injector and passing upward with the fly wheel and governor, and from thence into minor improvements in valves and cut-offs and two or three score of modifications and devices which arrived at steadily expanding efficiency. Improvements in boilers, grates and tubes to generate greater heat and to the greater production of steam and its more economic use followed in quick succession, until to-day the steam engine seems to have been placed on the pinnacle of inventive ability. This interesting and wonderful industry must be understood from its infancy in order to comprehend the steam engine of to-day.

Requirements.—The locomotive has probably reached its maximum size and capacity until some means can be found to improve the boiler.

Failures of boilers to meet requirements are growing somewhat frequent when put to severe tests. There is urgent need of more reliable and more serviceable boilers, and master mechanics and engineers are giving the subject close attention.

Another improvement needed is greater tractive power. The tendency is to use two or three units of moderate capacity. To attain this result an engine consisting of two six-wheel connected engines has been built at Schenectady, which is designed to secure the maximum of tractive power.

The four-cylinder engines of the De Glehn type develops high tractive power in cylinders and in machinery of medium size where the crank axle is required to transmit only one-half the total cylinder power. Experience shows that where the power from four cylinders is transmitted through a single crank axle, failure will occur through the heating of the inside main-rod bearings and the breaking of the crank axle.

It is demonstrated in locomotive practice that until boiler design and boiler waters are improved, boiler pressure will not be increased above 200 pounds.

The orders for compound engines are falling off because they do not receive the care they demand at the roundhouses. It is the most economical engine when properly cared for.

Features of a Steam Engine.—Two cranks at right angles are frequently used to obtain greater regularity of revolution.

The fly-wheel of an engine, as all know, serves to store up work. The conditions under which the best form of fly-wheel are used call for fine mechanical skill. The most advantageous angle between the cranks is 90 degrees.

An important problem is the influence of the point of cut-off and the length of the connecting rod on the fly-wheel. The mean diameter of a fly-wheel is usually taken at from 3 to 10 times the length of the stroke.

The Fly-Wheel.—The area of the cross section of the rim of a fly-wheel is found by knowing the weight and the mean diameter of the rim of the wheel. In balancing a fly-wheel great care is necessary to have its center of gravity coincide with its axis. Economy of weight of wheel is secured by increasing the speed of the rim.

Link Motion.—Valve motions actuated by a weight or spring released automatically by the centrifugal governor have been elaborated with great skill and are excellent for average speed. Where high rotative speeds are desired the cut-off of the engine is actuated by means of a link or eccentric whose position is regulated by means of a centrifugal governor, and whatever the speed, the valves must keep pace with the engine in its motions. Fink's link motion is regarded as the simplest reversing gear, which at the same time can be adjusted as a cut-off. Meyers' link motion has met with the greatest favor among builders of marine and stationary engines.

Superheating.—The superheating of steam has two consequences: the temperature is increased beyond its temperature of saturation and its specific volume is increased at the same time.

The jet condenser is a cheap and efficient device. The surface condenser should be used only when it is necessary to separate the condensing water from the boiler feed water.

The compound engine owes its greater efficiency to the nature of the iron rather than to the properties of the steam, and with the greater use of non-conducting materials the necessity of compounding will decline.

Law of Condensation.—The law of condensation is as follows:

(1) The difference of the temperatures of steam at the point of cut-off and while being exhausted.

(2) The area of the cast iron exposed to the entering steam up to the point of cut-off.

(3) The time of exposure of the interior surface of steam cylinder to the exhaust steam.

The Governor.—Governors are throttling governors, cut-off governors or centrifugal governors and inertia-resistance governors. Both classes, with one or two exceptions, rely upon the centrifugal force or inertia of revolving balls or weights to cause a change in position in themselves and to adjust the valve under their control. It is attempted to produce a steady motion by putting a sensitive governor on an engine having too light a fly-wheel; the result is that the governor pumps up and down, thus adding to the irregularities of the engine. A governor must have power so as to handle its valve without being affected by the slighter forces due to inaccurate workmanship or adjustments.

Comparative Summary of the Locomotive Industry.

	1890	1900
Number of establishments	19	28
Capital invested	$24 516,574	$40,813,793
Wage-workers	15,678	19,039
Wages paid	$8,697.488	$10,899,614
Value of products	$19,752,469	$27,121,063

Lumber Manufacture.

Logging and Planing Mills.—The lumber industry is divisible into logging, sawmill and planing-mill branches. It is fourth in the list of industries of the United States, and according to the last census there were 3,035 establishments engaged in manufacturing, with a total capital of $611,611,524, employing 283,260 wage workers, to whom was paid $104,640,591 in 1900.

Products.—Sawed lumber forms 81.2 per cent.; shingles, 3.9 per cent.; cooperage materials, 3.6 per cent.; telegraph poles, railway ties, etc., 3.3 per cent., and all other products 8 per cent. Yellow pine is the chief product, amounting to 37 per cent. The cut of white pine is 21.5 per cent; hemlock, 9.8 per cent.; red fir, 5 per cent.; spruce, 4.2 per cent.

Hard Woods.—Of the hard woods, more than one-half are found in oak, or 51.4 per cent. of hard woods; poplar, 3.2. The three States on the Pacific coast contain at least one-third of the standing timber of the country. The three States of Michigan, Wisconsin and Minnesota furnish about 27 per cent. of all.

Logging.—Logging is largely conducted in the winter time, to take advantage of the snow. Logs are moved principally by animals, sometimes dragged by wire cable, operated by donkey engines. In the southern sections of the United States lumbering goes on all the time, as well as on the Pacific coast. In the Sierra Nevada mountains traction engines are largely used for hauling.

Chief Varieties.—The chief commercial varieties of lumber are yellow pine, white pine, spruce, hemlock, cypress, cedar, white oak, red oak, red fir, black walnut, redwood, elm, ash, basswood, cherry, maple and chestnut, although these do not by any means exhaust the list of woods in common use.

White Pine and Spruce.—The greatest bodies of white pine are to be found in the northern portion of the Lake States. The supply is steadily declining, and lumbermen are obliged yearly to go longer distances for material. It is estimated that there are probably 50,000,000,000 feet of white pine standing in the country. It is also estimated that there is about the same quantity of spruce in the Eastern States, found mainly in New England and New York.

Hemlock.—The total amount of hemlock reported by lumbermen is 6,755,000,000 feet. It does not grow anywhere as a pure forest, but is intermingled with other species.

Cypress.—Cypress is a tree of low, marshy regions, found along the Atlantic and Gulf coasts, and latterly has come into very general use. The reported supply is 6,562,000,000 feet.

Yellow Pine.—Yellow pine is found largely in the Southern States, and covers an area estimated approximately at 150,000 square miles, or about 100,000,000 acres. About 15 per cent. of the total is directly controlled by the lumbermen.

Western yellow pine is found over a large section of the West. The total supply in the States of Washington, Oregon and California is estimated at 125,000,000,000 feet.

Sugar Pine.—The sugar pine tree is found mainly on the western slope of the Sierra Nevada range, about 3,000 feet above the sea, and as high as 9,000 feet. It is a large tree, 5 to 10 feet in diameter and about 250 feet in height. The wood is fine, splits easily and is a valuable timber. The supply in California and Oregon is estimated at 25,000,000,000 feet.

Hard Woods.—The hard-wood area covers the eastern portion of the Upper Mississippi Valley and the central portion of the United States. The principal woods are oak, gum, poplar, maple, cottonwood, elm and ash. The area covers several hundred thousand square miles. The total cut in 1900 was 4,438,000,000 feet.

Red Fir.—Red fir is distributed over the Rocky Mountain country and is found at the sea level of Puget Sound and at heights ranging from 300 to 6,000 feet. The red fir ranges from 200 to 300 feet in height and is from 3 to 20 feet in diameter. The stand is heavy, as much as 50,000 feet to the acre being often cut. It is a timber of great strength, and is now being largely used in the East, and is also exported to all parts of the world. It is estimated that the supply is equal to about 300,000,000,000 feet.

Redwood.—Redwood is found only in a narrow strip closely bordering the Pacific coast, the strip ranging from 5 to 25 miles wide and approximately covering 2,000 square miles. The trees are large, have an average diameter of 5 to 10 feet, and in some cases 20 feet. They range up to 300 feet high, and the average stand is nearly 60,000 feet per acre, and in localities from 100,000 feet to 150,000 feet. It is a strong and durable lumber, and is used for almost all purposes. The supply is estimated at 75,000,000,000 feet. The lumbering and milling operations are carried on mostly by large companies, and the most modern methods and machinery are employed. No better equipped mills can be found in the world for handling the stock from the stock logs to the diversified product.

Among the kinds of timber worked up are yellow pine, white pine, hemlock, redwood, spruce, cypress, cedar, Norway pine, red fir, sugar pine and tamarack. Among the hardwoods are ash, birch, chestnut, cottonwood, elm, gum, hickory, basswood, oak, poplar, black walnut, maple and sycamore.

Among the leading products are timber for construction purposes, lumber for all manner of building, shingles, lath, planing-mill products for interior finish, telegraph poles, railroad ties, piles, paving stock, wheel stock, carriage and wagon stock, cooperage stocks, including hoops, staves and headings, furniture stock, agricultural implement stock, pickets and palings, basket stock, excelsior stock, fence posts, hop poles, hewn timber, ship and car stock and oak and hemlock bark.

Yellow pine furnishes the largest supply, as measured by feet, viz.: 10,603,108,000 feet, worth $90,903,556. White pine output in 1900 was 7,483,283,000 feet, worth $94,979,885, Hemlock was in volume about one-half in quantity and value that of white pine. Red fir was valued at $15,050,638, and spruce, $16,322,666.

In the hardwoods, oak leads, with a production in 1900 of 4,438,027,000 feet, worth $61,174,129. Poplar followed with 1,115,242,000 feet, worth $15,646,331. The respective quantities of other woods ranged from 100,000,000 to 500,000,000.

Shingles are largely made from cedar, though white pine and cypress are considerably used.

The improvements in saw manufacture have been numerous and important. An old-time fault was that saws were not free from cavities formed in the ingots and which, when occurring near the teeth, caused that portion of the saw to split, spall or crumble. This drawback has been practically overcome. By reason of practically perfect material, good tempering, good foundation and good saw-setting, greater speed and consequently greater economy is effected. A speed of 10,000 feet per minute on the run is obtained in a 72-inch saw running 530 revolutions per minute, 600 revolutions in a 64-inch saw, 815 revolutions in a 48-inch saw, 1,080 revolutions in a 36-inch saw, 1,630 revolutions in a 24-inch saw, and 3,260 revolutions per minute in a 12-inch saw.

In the usual gauge of large circular saws, used in the ordinary manner on the average feed of lumber, $\frac{3}{32}$ of an inch equally divided, is about as little clearance as should be run, except in hardwoods and frozen timber. A thin saw requires as much clearance as any other, consequently, in proportion to thickness, the thin saw has the most strain to bear.

Speed.—Regularity of speed is especially necessary with thin saws, as they depend more than others on velocity to hold them up to their work. In extra thin saws, one-sixth more speed is required than the tables usually call for.

Comparative Summary of the Timber and Lumber Industry.

	1880	1890	1900
Number of establishments	25,758	22,617	33,035
Capital invested	$181,465,392	$557,881,054	$611,611,524
Wage-earners	148,290	311,964	283,260
Wages paid	$31,893,098	$87,934,284	$104,640,591
Value of products	$233,608,886	$437,957,382	$566,832,984

Comparative Summary of the Planing-mill Industry.

	1880	1890	1900
Number of establishments	2,491	3,670	4,204
Capital invested	$38,070,593	$120,271,440	$119,271,631
Wage-earners	37,187	79,923	73,627
Wages paid	$14,431,654	$42,221,856	$38,685,210
Value of products	$73,424,681	$183,681,552	$168,243,008

Machinists and Machinery.

Importance of the Machinist. — Perhaps the most important handicraft in the realm of mechanism is that of the machinist. With each improvement in mechanism the importance and value of the machinist increases. He is as the mainspring to the watch, the power behind the throne, whose knowledge and skill make possible the wonderful achievements of modern civilization. Perhaps no other craft is as developed and specialized. Latent mechanical capacities of the human mind finds room for activity in the vast network of appliances, devices and agencies which find their origin in the drafting-room or workshop.

The Machinist in Early Times.—To attempt to trace the origin and development of the mechanic arts would be difficult. The early implements were stone and wood. First came what answers to our modern hatchet; then the hammer followed, and finally an instrument to make holes in wood, flint, shell and iron was devised. The early mechanic possessed the instincts of the modern carpenter as well; when it became necessary to put two pieces of wood together the mechanical instinct began to express itself. It was this necessity that brought the auger into existence in the early ages of mechanical art through the ingenuity of men who found means to get metal out of a certain kind of stone. The auger might be regarded as the basis of the mechanical art. Next came the chisel and then their varieties. From the early auger there were numerous steps to the drill of to-day with its various applications.

Drill and Lathe.—The introduction of the drill constituted an epoch in mechanism and laid the foundation for a great industry. With it came taps and dies for a variety of work. From this simple beginning to the lathe of to-day the steps were gradually taken; it was simply a development of the potter's wheel. Drills may be spoken of in two general classes—flat and twist. With the employment of power a revolutionizing process set in, which transformed a simple industry into a complex and vast and far-reaching industry. The lathe brought into use, lathe chucks with their many jaws, usually three or four, and lathe dogs and mandrels and a variety of boring tools as the ingenuity of the mechanic developed and new and more complex necessities presented themselves.

Types of Screw-Thread.—It was an easy and natural step to cut a thread on the end of a piece of iron to assist its holding power. There are five types of screw-threads used in this country; the V-thread, the Sellers thread, which has an angle of 60 degrees; the square thread, used where the thread and space are the same width; the Whitworth thread, the sides of which form an angle of 55 degrees instead of 60 degrees, and lastly the Acme thread, similar to the square form. The difference is that the sides incline 14½ degrees from those of the square thread. A standard has been adopted known as the United States standard, in which the diameter of screw ranges from ¼ inch with 20 threads to the inch to 6 inches diameter with 2¼ threads.

The Drill Press.—The drill press marked another advance, which was improved with a back gear to increase the range of available speeds. The radial drill followed in great variety and efficiency to increase the output of the shop.

The Mechanical Planer.—An important point was reached when the planer appeared, which is a machine for finishing flat surfaces; with it came a number of appliances for moving the work in using the tool. Next followed the shaper, which moves while the work is at rest. The slotter is a shaper with the tool moving vertically instead of horizontally, and is used for working on heavy pieces and especially when an irregular contour is to be formed.

The Milling Machine.—The next step of progress was the milling machine, used for the finishing of flat or curved surfaces by the use of rotating cutters. These machines demand great care from the machinist. It is necessary to prevent chips getting into the holes in the spindles or between the arbor collars. When at work the milling cutter is kept flooded with oil or a solution of sal-soda. To prevent unnecessary friction, wear and tear, the cutter is generally used in milling a large number of pieces of steel, wrought iron, malleable iron or tough bronze. Some recommend the use of lard oil in milling, but any animal or fish oil may be used and then separated from the chips by the use of a centrifugal separator by dumping into a tank of water.

Rules of Speed and Feed.—It is impossible to give definite rules for the speed and feed of mills, but it is usual to run at the highest possible speed. The average speed on wrought iron and annealed steel is perhaps 40 feet per minute, which gives about 60 turns per minute with mills 2½ inches in diameter. The feed of work for this surface speed of the mill can be about 1½ inches per minute, and the depth of the cut about $\frac{1}{16}$ inch. In cast iron, a mill can have a surface speed of about 50 feet per minute, while the feed is 1½ inches per minute and the cut $\frac{3}{16}$ inch deep In tough brass the speed may be 80 feet, the feed the same as in cast iron, and the chip $\frac{3}{32}$ inch.

English Rules.—Addy, an English authority, gives a safe speed for cutters of 6 inches in diameter and upwards, as follows:

Steel—36 feet per minute with a feed of ½ inch per minute. Wrought iron—48 feet per minute with a feed of 1 inch per minute. Cast iron—60 feet per minute with a feed of 1⅔ inches per minute. Brass—120 feet per minute with a feed of 2⅔ inches per minute.

A Standard Rule.—A good rule for obtaining speed is, the number of revolutions which a cutter should make when working on cast iron, viz.: 240 divided by the diameter in inches. A mill known as the end mill can be used in many places where the face mill cannot be applied. The milling machine is extensively used in place of the planer; it is valuable for finishing irregular surfaces and is used for cutting the teeth of the gears.

The Grinding Machine. — For purposes of obtaining greater economy, the grinding machine is used. With such a machine round surfaces may be ground to vary from the nominal diameter by only .0001 inch. The object of the grinding machine is to reduce to accurate dimensions the work turned out on the lathe. The speeds of some grinding wheels are as follows: For diameter of 1 inch, 19,000 maximum revolutions per minute; 1½ inches, 12,500 revolutions; 2½ inches, 8,800 revolutions; 4 inches, 5,500; 8 inches, 2,770 revolutions; 14 inches diameter, 1,580; 20 inches, 1,100 revolutions; 26 inches diameter, 850 revolutions per minute.

Laying Out Work.—The skill of the machinist is displayed in the laying out of his work. It is necessary in certain lines of work to cover the surface of the work where lines must be visible with chalk, white lead or copperas, before any laying out can be done. There must be a base line to which all other lines are referred.

Best Methods.—The constant question arising in the shop is the best method of doing each separate piece of work. Method is second only in value to knowledge in all shop work.

The importance of method in the prosecution of machine shop work cannot be overvalued, especially since the very general use of economic mechanical appliances.

Valve and Joint Work.—The grinding of valves is usually done by hand. Fitting brasses is usually done on a machine. Joints are made securely tight in various ways. When a joint is to be permanent the red-lead joint is usually employed. The red lead has a tendency to rust and thus form a very tight connection. A disk of rubber packing answers where a joint is liable to occasional disconnecting. Where joints are frequently taken down they are packed with a piece of copper wire. Joints are also made by the rusting of two surfaces together.

Shafts and Belts. — When castings are to be worked either in the lathe or planer to dimensions only a little less than that when rough, they should be picked. The lining of shafting calls for great care; after this comes the setting of machines. Following this comes the belting; usually, leather is used in from one to six ply and of suitable width. Leather belting is injured by water, steam, or oil and above a temperature of 110 degrees.

Belt Power.—The power transmitted by a belt is directly proportional to its speed and width. A safe rule is to allow one horse-power for a speed of 1,000 feet per minute with a single-thick belt one inch wide.

Field for Mechanical Appliances.—Machinery is of such diversified character and is used for the performance of such a variety of work that all the books that have been laboriously written upon it do not reveal a tithe of its adaptabilities. The introduction of steam opened wide the door of mechanism for the doing of a vast variety of services to man, from the stove that furnishes him warmth to the locomotive that enables him to travel at great speed. Metal, chiefly iron and steel, on one hand, and steam on the other, have been the giant factors, and man in his efforts to use them with steam as a power has vastly multiplied his power over nature and has developed a mighty material civilization. Iron or steel is the basis of tools, machines and mechanical appliances of endless shape and purpose, used either by muscular power or actuated by steam or gas or other force for the doing of useful work.

The Work of the Machinist.—It is the work of the machinist to fashion this substance according to methods and rules developed by experience and study into shapes and combinations whereby it can permit the natural forces to exert themselves, guided by human intelligence and wisdom, to wise and beneficent ends under the broad term, machinery.

The Utilization of Power.—Force exists, and it is man's opportunity to devise methods by which it can be best directed to his good. The machinist is the high priest in the temple whose handicraft and skill enables him to accomplish this purpose. Machinery in its multiplied forms and for its innumerable uses is but the expression of man's creative intelligence stamped on matter.

Magnitude of the Industry.—There are in the United States 512,254 establishments where machinery is used, employing 5,308,406 wage workers, using or coöperating in the use of machinery, to whom were paid in wages in 1900, $2,322,333,877 and who produced goods in that year having a market value of $13,004,400,143.

To attempt to describe or classify the work done by these over five million workers in these half million establishments would be futile. And yet the work done is fundamentally the same but diversified by reason of the vast and endless diversity of forms of work necessary to serve the requirements of man.

The growth of the mechanical industries is shown in the increase in invested capital, which in 1880 amounted to $2,790,272,606, to $9.817,434,799 in 1900, an increase almost three and one-half fold in twenty years. The increase of the value of products during that period was two and one-half fold over 1880.

Malt and the Malt Industry.

Malting Process.—The process of malting consists essentially in converting the starch of the grain into saccharine matter, when it is dried and is then used in brewing ale, beer and porter and in the distillation of whiskey.

Growth of Brewing.—The brewing of malt for the past half century has been of uniform and uninterrupted growth. The manufacture of lager beer in the United States began about 1840; its use extended with the general increase of population and with influx of German immigrants and the rapid cultivation of the tastes of the people for milder beverages. In 1890 its use had almost superseded that of ale and porter.

Localization of the Industry.—The manufacture of distilled liquors from grain, owing to the fact that the product is less bulky than the raw material, has tended to localize the industry at points where the cereal supply is ample and the cost the least. In the manufacture of malt liquors, the transportation of the finished product involves greater expense than that of the materials used. The industry has assumed enormous proportions, as is evident from the most cursory reference to statistical authorities. The consumption of beer is an evidence of the changing tastes of the people in beverages.

Fifty Years Ago and Now.—Fifty odd years ago the consumption of beer in the United States was under $6,000,000 in value; the consumption at the present time is in the neighborhood of $250,000,000 annually. The capital employed in 1900 was $415,284,468, an enormous amount of capital for an industry of such comparatively recent growth. Beer, to a certain extent, therefore, seems to be accepted as a liquid substitute for breadstuffs. The consumption is steadily increasing per head of population, notwithstanding the growth of the sentiment of a prohibitory character in many sections of the United States.

Ale.—Ale is an intoxicating liquor made by infusing malt in hot water, then fermenting the liquor so formed and adding a bitter, usually hops. It differs from porter in having a less proportion of roasted malt. It was the favorite drink of the old Germans and the Anglo-Saxons. The old Welsh and Scots made two kinds—spiced and common.

Porter.—Porter is a dark-colored malt liquor and derives its name from the peculiar fact that it was originally a favorite drink of the London porters.

Comparative Summary of the Malt Industry.

	1880	1890	1900
Number of establishments	216	202	146
Capital invested	$14,390,441	$24,293,861	$39,2[illegible]8,102
Wage-earners	2,332	3 238	1,990
Wages paid	$1,004,548	$1,590,175	$1,182,513
Value of products	$18,273,102	$23,442,559	$19,373,600

Marble and Stone Work.

Rapid Growth.—The cutting of marble and stone during the past two decades has practically trebled. One reason for this rapid growth is to be found in the growing preference for stone and marble as against lumber, or even iron and steel in construction for residences and public buildings. Architectural taste is stimulating the demand for stone work in residences, churches and public buildings of various kinds, in fact, it might be said, without exaggeration, that the use of these products for public buildings and for rural and suburban residences is becoming general, particularly among the wealthier classes.

Stone-Working Appliances.—The mechanical appliances for preparing stone have improved greatly, especially during the past ten years. Deposits of granite and stone of various kinds have been uncovered which, with a moderate amount of labor and by the use of highly perfected machinery, have become almost inexhaustible sources of supply. Stone or marble is more attractive than steel or lumber, and more durable and less liable to danger from conflagration; from every point of view they are more desirable for large structures than any other material. The appliances for removal from the quarry are also much improved, and allow the work of quarrying to be done at a much less cost.

Varieties of Artificial Stone.—There are various varieties of artificial stone and the favor with which they are received by architects and builders is resulting in their greater production. The activity of inventors in this direction is illustrated by the fact that 1,204 patents have been issued for the production of artificial stone. One of the recent methods for making artificial marble is the treating of dehydrated gymsum with various colored solutions. The stone is very attractive. The fundamental principle in most of these patented processes is grinding and admixture of various ingredients to form a compact mass.

Appliances for Mixing Mortar.—The appliances for mixing the plaster used are various. One of the most improved is a drum mixer, the drum rotated by the action of the wheels of the vehicle carrying the mixture, and the concrete is mixed as it is being transported in the vehicle to the place of use. There are several concrete mixers on the market which possess most valuable features. Many complete paving plants on wheels are used, to be moved from place to place, in order to have all needed facilities on the ground with the least possible delay.

Glass Stone.—Another imitation stone is made from waste glass fused and devitrified in a suitable furnace. It is used for paving-blocks; because of the devitrification it is not slippery and fragile like ordinary glass. It has, however, met with moderate acceptance. The source of supply is limited.

Comparative Summary of the Marble and Stone Work Industry.

	1880	1890	1900
Number of establishments...	2,846	3,373	6,070
Capital invested............	$16,498,221	$37,115 193	$67,509,533
Wage-earners...............	21,471	31,728	54,370
Wages paid......	$10,238,885	$21,342,623	$28,663,241
Value of products...........	$31,415,150	$62,595,762	$85,101,591

The practically trebling of the production of the industry in twenty years is evidence of the general expansion of the uses of these materials of construction.

Masons, Stone, and Masonry.

History.—The stone masons of ancient times were among the most important craftsmen and the work which has come down to us through all the ages is a standing monument of their skill. The ancient temples, the Pyramids and vast buildings still standing show that the art of stone-cutting reached a very high degree of excellence and exactness, long before many of the handicrafts were thought of. In our own day there is a gradual returning to stone for construction, especially for large buildings in which architectural considerations are an important feature. In selecting stone, the architectural builder takes into consideration, aside from quality, the heat and cold to which the stone may be subjected, the nature of the atmosphere, the position of the stone in the building and the manner of dressing.

Designations.—Rough stone from the quarry is usually designated under two heads—rubble and dimension stones. Rubble includes pieces of irregular size. Stone ordered of certain size or to square over 24 inches each way and a particular thickness is called dimension stone, although this definition does not cover the classification fully. Rubble is generally sold by the perch and dimension stone by the cubic foot. Moldings, belt courses and cornices are usually figured by the lineal foot, carvings by the piece.

Defects.—Good granites are liable to contain local defects, such as seams, or white or black lumps called knots; also brown stains known as sap. Seams can be detected by striking the stone with a hammer; the most common defects in sandstones are sand holes; patching is sometimes done by means of glue and melted shellac and then rubbed in with stone dust, but the patching is not permanent. In dressing rubble, the customary tools are the axe, or hammer, the tooth-axe, the bush hammer, the crandall, the patent hammer. There are various kinds of finish. One is known as rock face, with margin lines often called draft lines, and cut with a tool chisel in soft stones or in granite with an axe. Other styles of work are termed broached work and pointed work.

Dressing.—The cheapest method of dressing soft stone is by a tooth chisel. Tooled work is done with a flat chisel from 3½ to 4½ inches wide, wherein the lines are continued clear across the width of the piece. Drove work is much like tooled work, but it is done with a chisel somewhat narrower and in rows lengthwise of the piece. Bush-hammered finish is made by pounding the surface of the stone with a bush hammer, leaving it full of points. It makes a very attractive finish for the harder kinds of sand and limestone, but should not be used on soft stones. Crandalled work gives a fine pebbly appearance when thoroughly done, and makes a sparkling surface for red sandstone, but the crandall is not used on granite or other hard stones. In picked work, the face of the stone is first leveled off with the point and then picked all over as though a woodpecker had picked it.

Finish.—When it is desired to give a finished surface to granite and hard limestones, they are first dressed to a rough surface with the point and then to a medium surface with the same tool and finally finished with the bush hammer. The fineness of finish is determined by the number of blades in the hammer and work is said to be six-cut or eight or ten-cut, according as 6, 8 or 10 blades are used. The same finish may be obtained by an axe, but it requires more time.

Vermiculated Work. — Vermiculated work is that which looks as if it had been eaten by worms. The term "rusticated" work is used to denote sunken or beveled joints, although it usually refers to work honeycombed all over the face to give it a rough effect. Work done to imitate hammered brass is sometimes termed "fish scale," and it is done with a tool with rounded corners.

Sills.—Sills are spoken of as slip sills and lug sills. The former are not likely to be broken by a settlement of brickwork and for this reason are much used. Stone arches are frequently used in stone and brick buildings, but a stone arch is more liable to settle and break than a brick arch.

Varieties of Work.—It is usually considered that masonry requires more skill than brickwork. Masonry is classified as ashlar or rubble. Ashlar is built from large blocks of stone while rubble is composed of small stone. Between these two are many variations and different kinds of masonry are often combined in the same work; thus walls are built with ashlar facings and with rubble backing or with stone facings and brick backing, which latter leads sometimes to defective construction. In ashlar masonry the joints do not exceed one-eighth or one-tenth of an inch in thickness, and the size of blocks varies with the nature of the stone. Ashlar masonry is the most expensive and depends for its strength on the size of stones, accuracy of dressing and the perfection of the bond, and very little on the mortar, which must be very fine and free from grit.

Joints and Bonds.—Great attention should be given to the bond in all kinds of masonry. On the face, the vertical joints should break upon every stone; no straight joints are allowable. The bond across the thickness of the wall is of still greater importance.

Ashlar Walls.—Coursed ashlar walls consist of blocks the same height throughout the course. Squared rubble built in courses is brought to a level course throughout its length at every ten or fourteen inches. Coursed header work is rubble, excepting that the header or bond stones are each of the full depth of the course in which they occur. Regular coursed rubble consists of stone, laid in courses, each and all being of the same height. Dry rubble is that built without mortar; it is the cheapest kind of work but requires considerable skill. Flint rubble is composed of flint and pebbles or popples laid in mortar. Walls so built are frequently strengthened by building lacing coursings in with them. Blocked course masonry is intermediate between ashlar and rubble. The expense of ashlar facing prevents its being used throughout the whole thickness of the wall.

Other Methods of Jointing.—There are several methods of giving greater strength to joints of masonry than that afforded by the adhesion of the mortar and the weight of the stone. Among these are metal connections, joggle joints, dovetailed joints, ground and tongue joints and others.

Stone Cements. — There are various stone cements, among which may be mentioned some which can be used in practice, others not. One cement is made of 1 part sulphur, 1 part yellow wax, 1 part rosin. The sulphur and rosin are melted and the wax is added. The cement must be applied when hot and pressure is continued until cold.

Other Stone Cements.—Another cement is made of 2 parts powdered gum arabic, 2 parts finely ground white lead, 1 part pulverized sugar candy. Hot water is added and then stirred into a paste and kept in a closed vessel. These cements are not applicable in large operations.

Artificial stone is made of 2½ parts finely pulverized slag, 2½ parts ground fire-brick, and 1 part Portland cement, run into molds forming chimney pieces, window-heads, sills, balustrading, wall coping and other ornamental work for builders, as well as pathing for footpaths and stables.

A cement for repairing broken stone is made of 2 parts, by weight, of oxide of zinc, 2 parts crushed grit, mixed and ground, to which ochre may be added for color.

Another cement for mending broken stone is made of 10 pounds clean river sand, 1 pound litharge, ½ pound quicklime, with sufficient linseed oil to form a thin paste.

Preserving Stone.—The only effective means of preventing crumbling of stone, blowing or exfoliation is to so cut the blocks as to be seated in the structure on their natural beds; that is, horizontally parallel to the direction of their natural fissures, which, in the rock, keep the direction of the dip. The reason is, that water coming into contact with the external surface of a stone, of which the natural fissures are set perpendicular or at a high angle, will inevitably be admitted into those fissures, and it will follow them down by gravitation and fill the fissures with water. The frost congeals and expands and "blows out," and causes exfoliation.

Nature of Stone.—When, on the other hand, the stone is laid on its natural bed and the fissures and laminæ are horizontal, all wet falls harmlessly down the face of the stone, being excluded from the substance. Most kinds of stone are subject to such action. They can be preserved by proper placement and become externally hardened by exposure to action of air and water, and thus a slow process of normal crystallization sets in.

Masonry.—Masonry, like carpentry, to which it is intimately related in practical work, is becoming a more important handicraft. The handicraft of the mason has been developed under a number of influences, such as the demand for stone for public buildings and residences, the ease with which stone can be quarried with improved modern appliances and cheaply transported from quarries to destination, to the greater attractiveness of buildings constructed of this material and to its greater endurance and greater ultimate economy of stone structures.

Art of Construction.—The development of the art of construction and the erection of buildings of enormous size and height, call for deeper, stronger and broader foundations, for larger individual pieces or blocks and for greater care in their placing.

The Aid of Engineers.—The craft has, under the lead of civil and mechanical engineers, who have studied deeply and highly developed the science of masonry in its relation to the support of large structures, arrived at a high degree of mechanical excellence. With all our progress, however, the manner and process of joining stone to stone as was done in ancient masonry, especially as shown in the Pyramids, has not reached ideal perfection. The use of what is termed unhewn stone is increasing for a number of uses, and is much favored by architects where the desired effect can be heightened.

Constructing engineers are departing from old-time methods and ideas and rules as to material of construction as well as to methods of construction and are developing a type of building in every respect superior to all past achievements.

Comparative Summary of the Masonry Industry—Brick and Stone.

	1880	1890	1900
Number of establishments ..	1,591	7,715	8,333
Capital invested............	$3,990,706	$54,669,408	$48,070,239
Wage-earners...............	16,020	110,618	93,568
Wages paid.................	$6,880,866	$69,311,083	$53,152,258
Value of products..........	$20,586,553	$204,165,642	$203,593,634

Match Making.

Match Making.—In early times the term "match" was applied to the wick of a candle. Matches are spoken of in ancient times, but no information comes down to us by which we can know how minute temporary conflagration was affected. A match has been defined as anything used for catching and retaining or communicating fire. It is made of some substance which readily takes fire or remains burning for some time, and consists of a small strip or splint of wood dipped—one end—in a substance easily ignited by friction. Preparations of phosphorus or chlorate of potassium have been used for this purpose as well as many other chemical materials.

Progress in Ideas.—The history of match making is interesting and shows a collection of discoveries, inventions and experiments more or less successful and which finally culminated in the matches of to-day. The old sulphur match in its time was regarded as a triumph of mechanical and chemical genius in its time, and served its purpose until a wider knowledge of chemistry enabled a more useful and acceptable match to be produced.

Classification.—Matches are sometimes classified as chlorate, English, friction, safety, silent, Swedish, vestas, Vesuvius and many other kinds. Ordinary matches are small slips of wood which have been dipped in sulphur and afterward tipped with a paste capable of ignition by friction. This paste is made up of usually 4 parts common phosphorus, 16 parts nitre, 3 parts red lead, and 6 parts strong lead, but the compositions are various. Friction matches are made of fine glue, phosphorus, potassium chlorate, powdered glass and water. Parlor matches may be made with red phosphorus, gum arabic, finely ground sand and binoxide of lead, and are perfumed by dipping in a solution of benzoic acid. Safety matches are made by dipping in a paste composed of chlorate of potash, sulphide of antimony and glue.

Silent matches are made with gum arabic, powdered phosphorus, nitre, vermilion and water in certain proportions, the whole worked into a paste.

Control of Supplies.—What is of more interest to the average reader is the mechanical appliances by which matches are made in such immense quantities at such a low price. It would be impossible to describe with any degree of satisfaction the multiplicity of devices or the variety and magnitude of the machinery used in one of the great match factories of the country. The companies control their own forests, saw mills and machinery for the preparation of the timber into proper shape, to be taken by the comparatively delicate machines which conduct the final stages of the work with lightning-like rapidity. Pages could be written descriptive of these appliances and of the perfection with which they are operated automatically; practically the match industry has developed into its enormous proportions within two decades and is now represented by a combination of millions of dollars. The combination of match manufacturers known as the "Match Trust" is one of the strongest among the smaller trusts.

Comparative Summary of the Match Industry.

	1880	1890	1900
Number of establishments	37	27	22
Capital invested	$2,118,850	$1,941,092	$3,893,000
Wage earners	2,219	1,696	2,047
Wages paid	$535,911	$473,556	$612,715
Value of products	$4,668,446	$2,193,638	$6,005,937

Matting and Basket Making.

Composition of Matting.—Matting is composed of a texture of coir, jute, rushes, hair, grass and palm leaves. Russia matting is made of bast or linden bark; it is also made of strips of black walnut or other ornamental wood with wires passing through them at right angles. The wooden strips are separated by elastic washers, made from India rubber tubing. On Russian rivers and canals the vessels have rigging and sails made of lime bast; the lower part of the bark is usually employed for roofing.

Chinese Matting.—The manufacture of China matting is extensively carried on in China and the plant from which the material is made is known as aquatic grass or russ. It is brought into the market in bundles of 12 inches in diameter, sorted, placed in large earthenware jars, soaked for three days, dried, soaked in liquid dye made from the chips of sapan wood, then dried five days, and next immersed in a dye three days, when it is ready for use. All kinds of matting are made practically in the same way. It is only within a few years past that green, yellow and blue colors have been used to any great extent. The matting is worked in looms similar to ordinary silk looms.

Employment.—Large numbers of people in China, Russia and other far Eastern countries find constant and remunerative employment in cultivating the plant from which matting is made. Enormous quantities are made for home and foreign use. As material for sails it is cheaper, if not more durable, than the ordinary canvas or sail cloth.

Uses.—Matting is used as covering for tea, sugar and cassia boxes, and also for money bags, which are very convenient for handling the silver money current in Asiatic countries. The number of mats made annually in the mat-making district of Russia is estimated at fourteen millions, which have a market value in that country of $1,500,000. A million lime trees are felled annually to supply the demand. Considerable skill is shown in the weaving as well as the dyeing of the material.

Floor Matting.—Large quantities of floor matting are made and a great deal of it is exported to the United States. In fact, matting occupies the sixth or seventh place in the products of China.

Basket Material.—The rods or willows from which baskets are made have the technical name of "ossiers." These rods are in much request in Europe by wine keepers, to use on wine casks. The shoots of the ossier are cut after the ground is frozen, bound in large bundles, placed in a tank, and, after standing until spring so that the bark can be easily torn off, the work of bark peeling begins. This is quite an industry, but it is restricted to limited localities and to families who follow it generation after generation. Carboy baskets are made of ossier. The black Spaniard variety is used for the bottoms, rims and handles of large baskets. It is largely used in France for the manufacture of ornamental baskets.

Basket Workmanship.—The utility and convenience of baskets, especially in domestic requirements, have created demands for baskets and willowware which has brought supplies from the four corners of the earth to supplement the limited but increasing supply from home sources. The basket and willowware handicraft is a developing industry, and each year is bringing into the market greater varieties of serviceable and more artistic workmanship. Willowware is also entering more largely into some of the industries, where numerous convenient receptacles are used with advantage. Rattan, of recent years, is also finding enlarged uses, which have led to its greater introduction and improved processes in its preparation for the market.

Statistics.—There are nine matting factories in the United States, employing 1,197 men, producing values estimated at $1,165,330. In straw plait matting Tuscany holds the first place. Straw is raised on the hills along the rivers Pisa and Elsa. The process of gathering and preparing it call forth much skill; nearly all the peasants understand the art of plaiting.

Comparative Summary of the Basket, Rattan and Willowware Industry.

	1880	1890	1900
Number of establishments..	304	403	550
Capital invested............	$1,852,917	$2,702,713	$2,989,968
Wage-workers	3,119	3,303	4,396
Wages paid..................	$657,405	$1,004,021	$1,280,511
Value of products.........	$1,992,851	$3,633,592	$3,851,244

Mattresses and Spring Beds.

Materials Used.—Mattresses are ordinarily filled with hair, moss, sponge, cotton, husk, straw and shredded wool, though other materials are being adopted for hygienic as well as economic reasons, which bring these necessary household comforts within the reach of all classes. The use of feathers for bedding was much more general a century ago than now, when ducks, chickens and geese were called upon to give up their coverings. The adoption of mechanical appliances for the manufacture of mattresses greatly increased the facility with which they could be produced, and the ease with which they could be handled in factories, for shipment and in households, led to their almost universal adoption.

Woven Wire.—The multiplication of spring beds followed the discovery of the quick and cheap production of wire. Since that time wire mattresses have become an essential requirement in households. Wire is now produced in enormous quantities at a surprisingly low cost, and it is worked up into springs, spiral and otherwise, and bound together in a way that allows the weight to be evenly and comfortably distributed. These springs possess valuable features, are durable and free from many housewifely objections, which insures cleanliness and comfort. The wire-spring industry has rapidly assumed large proportions, and a trade has been developed which extends over a large part of the world.

Comparative Summary of the Mattress and Spring Bed Industry.

	1880	1890	1900
Number of establishments..	357	696	797
Capital invested............	$1,749,750	$6.682,929	$8,298,772
Wage-earners...............	2,394	6,318	7,959
Wages paid..................	$868,325	$2,763,953	$3,213,268
Value of product	$5,288,234	$15,683,932	$18,463,700

Mechanism and Modern Progress.

The Touchstone of Modern Civilization. — The one word which spans the gap between ancient and modern civilization is Machinery. Ancient civilization possessed a very peculiar and glorious feature which no modern material progress can ever equal, but it was a civilization that might be compared to the oasis of the desert, in which the vast wastes of sand might be likened to the masses of the people and the oasis to the great centers of learning and the great scholars and thinkers of antiquity.

Modern civilization is characterized by its scope and by its power to reach far and wide and high and deep. It affects the masses of the people and is represented in their betterment, materially, intellectually and physically.

Printing First Incentive. — The first decisive step from out of the gloom of the mediæval ages was the art of printing, which cannot strictly come under the head of a mechanical appliance, as the hand did all the work; it laid the basis, however, for the remarkable after-progress, by arousing the intelligence of the world and stimulating its energies and opening up a broad vista of endless possibilities which promised abundant outlet and opportunity for all manner of activities of which the human mind is susceptible and capable.

Next the Steam Engine.—The first genuine and decided upward move on to the broader plane to which the world was then moving was the introduction of steam and the steam engine. What steam has done in the way of opening up opportunities for human activities can never be written. It would be impossible as it would be fruitless to follow the successive and uncountable steps upward from the early crude steam-using devices to the mammoth engines and power plants of the present day. The progress has been steady, uniform and irresistible. The progress of the nations and of the people has been measured very largely by the utilization of the agencies afforded by this wondrous power.

Transportation the First Aim.—The first efforts of the early mechanics who sought to utilize steam were to provide means for transportation of freight and passengers. The possibilities of steam laid the foundation for our present railway system and the basis of our vast industrial system. Human activities seized the opportunities thus presented, and in the wake of the steam engine sprang up a host of baby industries which were the kernels of the crop which has since produced a harvest of results. Early among the departures in the making of machinery was a manufacture of tools by which artisans could more readily and efficiently perform their work. Then came devices and equipment for the little forges and shops of Europe and America. For a long time mechanism seemed to halt. It was not until the opening up of the United States that the real stimulus was imparted which has made the mechanism of to-day what it is. It is true that in Great Britain, where the shipping interests long ago assumed such large proportions, shops, factories and engineering plants sprang into existence to furnish machinery to propel ships in all quarters of the globe, as well as to furnish mining equipment with which to mine coal, the basis of its industrial activity.

Minor Industries.—Next followed a multitude of minor industries coming under the general name of hardware, which supplied the necessities of households with conveniences and necessities for kitchen and dining-room. Following these came other departures in smaller channels, wherein were built up thousands of small shops which admitted of and necessitated the development of newer and different skill in the mechanic. The decentralization was rapid, and mechanical skill grew and developed. Stimulation, encouragement and energy were manifested in all avenues as the world began to realize that it had entered upon a new era of existence and had entered upon new and grander possibilities.

Coming of Iron and Steel.—The opening up of iron-ore mines in convenient localities, the development of rolling-mill appliances, the art of making iron and steel rapidly and cheaply, all acted as a mighty stimulus in the development of industries for the construction of machinery for the greater utilization of labor in a host of newly opening-up activities.

Popular Education.—Systems of popular education, which early became permanently established, aided in the development of a higher type of citizenship, and resulted almost simultaneously in the development of higher requirements, and which in time were met by the output of shops and factories. The masses of the people came to need and want more, and by their applied industry became able to buy and use more. From simple conditions of life, society on both sides of the Atlantic was transformed into more or less complex living.

Invention. — Industries rapidly decentralized and trades grew in number, and with the division, greater skill manifested itself. This led the way to invention. The conditions on this side of the Atlantic have been peculiarly favorable to inventive talent. The activities which our peculiar opportunities afforded, the general education of the people, the higher standards of life and living, the taste and appetite for comfort, the desire for wealth, and the determination of the masses of the people to rise out of the old and ascend into the new, to crawl out of the ruts of past ages and ascend on to the highway which progress is mapping out—all of these influences and many others united to stimulate a spirit of invention which brought into existence new methods of doing things through machinery, by which the power and efficiency of labor and skill were greatly multiplied.

Aim, Economy of Effort.—It would be impossible to even take a bird's-eye view of all the agencies which coöperated to bring about the age of mechanism in which we live. Economy of effort was everywhere sought after. Greater production from a given expenditure of time and force was the goal of invention. The achievements have been a marvel even to the achievers.

Results Accomplished. — The results accomplished are manifest in the spread of wealth, national, corporate and individual. The power of society to create wealth has been vastly increased. Labor finds abundant employment, and capital is tireless in pioneering the way into new fields after broader opportunities.

Ours the Leading Nation.—The American people, through the use of machinery, have become in the aggregate the leading nation on the face of the globe, because the benefits of increased capacity have been realized in fair measure by all.

Where Machinery Triumphs.—The greatest achievements in mechanism are found in our railway system, in our great plants for the production of iron and steel, for the manufacture of textile goods of every description, for the production of instruments, tools and machinery for the better cultivation of the soil, in the industries which supply material for construction of dwellings and buildings and for their proper equipment and furnishing; in plants which provide means for the transportation of water, oil and gas; in engineering plants which are turning out power, for specific purposes in units ranging from 1 to 20,000 horse-power; in the manufacture of engines of small horse-power for use among isolated producers of wealth in cities, towns and country, and in production of machinery for the preparation of wood, iron, stone, lumber and other equipment for untold uses.

Magnitude of Mechanical Industries.—Over 5,000,000 workmen are now engaged in this mighty industry, producing values estimated, according to the last census, at over $13,000,000,000. The capital invested in all of these aggregated industries in that year was placed at $9,817,434,799. The expansion of the mechanical industries is shown by the fact that in 1880 there was invested $2,790,272,606; in 1890 the investment reached $6,525,156,486; in 1900, $9,817,434,799. Wages paid in 1880 to the workers in these industries was $947,953,795; in 1890, $1,891,228,321; in 1900, $2,322,333,877. These figures show that, per head of population, including exports, $160 worth of manufactured products are provided for each person.

Further Statistics.—In 1880 the number of workmen engaged was 2,732,595; in 1890, 4,251,613; in 1900, 5,308,406. The number of establishments in 1880 was 253,852; in 1890, 355,415; in 1900, 512,254. These figures only faintly show the progress that has been made. They are simply figures and cannot portray the gigantic and titantic energies which are actuating the American people. These mighty forces and activities are still at work; capital is gathering itself together for still greater achievements. The wild incorporation of companies and combinations during the past few years shows the temper of the people and indicates their estimate of the opportunities in sight. Much of this activity may be feverish, much of it unwise, but it shows the drift of things and indicates the tireless energy of the American people.

Men's Furnishings.

Stimulation Given by Sewing Machines.—Following on the heels of the development of the clothing industry was that of the industry of men's furnishings. The decentralization of the greater industry into the lesser was natural and rapid. The introduction of machinery, especially sewing machines, stimulated this division, and factories sprang into existence for the manufacture of men's wear from the outer clothing to neck and footwear and underwear.

Statistics—The number of manufacturers engaged in men's furnishing decreased from 586 in 1890 to 470 in 1900, due to the centralization of factories. This is apparent from the fact that the production, which was valued at $29,870,946 in 1890, was valued at $43,902,162 in the census year of 1900. The number of wage earners increased in that decade from 20,778 to 30,216, of which 25,238 were women. The relative value of this industry is seen in the proportion of the value of its products in 1900—which was, as stated, $43,902,162—to the value of all textile products that year, which was $864,509,370.

Mirrors and Mirror Making.

Mirrors in Ancient Times.—The date of the invention of glass mirrors is not definitely known, but certain it is that human vanity and pride led to the production of some sort of means for reflecting the human countenance long ages ago. Ancient historians, among them Pliny, speak of mirrors as having been made at the celebrated glass houses of Sidon. Among the ancients mirrors were made of various metals, as bronze, steel, silver, etc. Mirrors of polished metal are now called specula.

Making of Mirrors.—The method of coating with tin-foil was known as early as the sixteenth century, when the manufacture of mirrors was first introduced on a considerable scale. The industry spread throughout Europe, and the artisans who acquired the art found their services in constant request, not only in the production of mirrors, some of them of wondrous size, considering the facilities at hand for their production, but they were called upon to add a variety of ornamentations which gave to the mirrors of those days an artistic value which is not equaled at the present time.

Shape of Mirrors.—Mirrors are either plain, concave or convex. Plain mirrors represent objects of their natural size; concave mirrors, or those having a hollow surface, collect the rays, reflecting them to a focus in front of the mirror, and consequently enlarging the image of the object; convex mirrors disperse the rays, and therefore diminish the size of the image of the object.

Extent of Industry.—The industry has within recent years assumed very large proportions, by the aid of a number of mechanical appliances which decrease the necessity for hand labor in the rougher operations. Very little change has taken place in the nature and quality of the materials used on the glass to reflect the image, although some progress is being made in the varieties and composition of material.

Statistics.—The extent of the industry is represented by the fact that there are over 100 establishments in the United States manufacturing mirrors, whose product is in excess of $8,000,000 per year. There are upward of 3,000 workmen engaged in these factories.

Silvering Solutions.—There are various compositions used in preparing mirrors, among which may be mentioned "Drayton's process," which is a mixture of silver nitrate, hartshorne and water. The Rochelle salts process is the most certain and simplest. One solution is made of nitrate in crystals dissolved in distilled water; another, ordinary powdered crystals of Rochelle salts in water, recrystallized. A well-tested silvering solution is made with 48 grains crystallized silver nitrate precipitated in distilled water with strong water of ammonia, then adding ammonia drop by drop, stirring until the brown precipitate is not quite redissolved, then filter and add distilled water to make 12 fluid drams.

Comparative Summary of the Mirror Industry.

	1880	1890	1900
Number of establishments..	7	45	103
Capital invested..............	$155,800	$1,695,772	$3,184,426
Wage-earners.................	77	1,404	2,555
Wages paid....................	$42,900	$842,407	$1,231,689
Value of products...........	$304,000	$6,000,533	$8,004,533

Model and Pattern Making.

Influence on Industrial Progress.—This is one of the most important industries in influence upon the arts and trades. Models and patterns enable unfamiliar and inferior skill to accomplish work beyond the ability of workers unaided. It is based on the faculty of imitation. The term is used by the sculptor to express the living model from which he studies and executes a figure. Models are made in clay, to be executed in marble, and also the plaster model, from this first figure. A great many industries are based upon models and patterns, as, for instance, wood working, foundry work, work in certain lines of iron and steel and leather, textile work of many kinds, and in the production of millinery. By following the outlines of models and patterns, and frequently drawings, a vast variety of useful work is done and works of art produced.

Universal Use.—The carriage-builder works from drawings, the makers of machinery, tools, castings and the vast array of mechanical equipments work from patterns. Apparel is also made from patterns and designs furnished; in fact, it is impossible to enumerate all the avenues of activity which are opened up to profitable employment through the use of models and patterns which guide the eye and instruct the intelligence how and what to do.

Comparative Summary of the Model and Pattern Making Industry.

	1880	1890	1900
Number of establishments...	233	456	532
Capital invested...............	$447,351	$1,594,804	$2,250,484
Wage-earners..................	815	1,627	2,608
Wages paid.....................	$421,857	$1,005,145	$1,565,728
Value of products...........	$1,020,650	$2,734,395	$3,836,518

Musical Instrument Making.

Names of Instruments.—Among musical instruments may be enumerated pianos, organs, violins, violoncellos, harps, guitars, banjos, drums, clarinet, flutes, concertinas, accordions, dulcimers, tambourines, trumpets, bugles, saxhorns, all of which are produced by American manufacturers.

Division of Work.—One interesting feature of the industry is the specialization of work into branches wherein only one part of the instrument is made. Piano making, for instance, has become merely the assembling of parts, and the number of wage earners has increased fivefold since 1860, the value of product sevenfold. This specialization has also extended into the organ industry.

Origin of Name "Piano."—The word piano-forte originated with an Italian musician in 1598, who spoke of an instrument which he called piano e forte, the Italian for soft and loud. Whether this referred to the piano as we know it is a question—most probably not. The piano succeeded the clavichord and harpsichord, each of which had a separate origin. Mozart used the clavichord in composing his masterpieces. The harpsichord was an evolution of the harp, which was usually inclosed in a box, where the wires were plucked mechanically by quills attached to the ends of each key. It was extensively used by Beethoven, Mozart, Handel and other eminent composers.

The First Piano.—An inventor in Florence, in 1709 produced an instrument capable of both soft and loud effects, in which the wire, instead of being pressed or rubbed by means of a wedge, as in the clavichord, or plucked by a quill, as in the harpsichord, was struck with a hammer which immediately rebounded.

Factories in England.—Zumpf built a piano factory in England in 1760, and Silberman one in Germany. Haydn and Mozart wrote compositions for it, but its general acceptance was due to Beethoven. The damper and soft pedals were introduced in 1780; uprights appeared in 1807.

First Pianos in America.—John Jacob Astor imported a piano in 1784, but John Behrent in 1775 built a piano, the first built in this country, at Philadelphia. Piano shops appeared in New York, Boston and Baltimore soon after. A "piano" is shown to-day which Washington had at Mount Vernon. After the war of 1812-15 with Great Britain, a number of young and skilled English piano-makers emigrated to the United States and gave a permanent stimulus to the industry.

Chickering.—Jonas Chickering, of Boston, introduced improvements between 1825 and 1840, one of which overcame the tendency of pianos to fall out of tune. This improvement was an iron frame cast in one solid piece, which allowed much greater tension of the strings and produced a better tone; a string stretched to its utmost limit yields its largest, purest and most brilliant tone.

Two Piano Schools.—Piano manufacturing in the United States is divided into what is known as the New York school and the Boston school. The full cast-iron frame originated in Boston, and was soon adopted in that city, when a piano became standard that was light in action, thin, sensitive, but very musical. The New York piano became Wagnerian in tone and instinct, a fact possibly due in a measure to the fact that most of the New York workmen are Germans or sons of German parents.

Square and Upright.—Up to 1866, 97 per cent. of all the pianos made in the United States were square, but since then the sweep has been in the other direction. In 1900, 97.4 per cent. were upright, 2.5 per cent. grand, and .1 per cent. square.

Mechanical Playing.—Since 1879, fifty-five patents have been issued in the United States for mechanical playing. In 1897 the first "Angelus," a cabinet piano-player, appeared. The popularity of this device is due to the fact that the performer is able to control tempo, volume of sound and accentuation of particular notes or parts.

Organs.—The "pan pipe" of the Greeks, a set of pipes of unequal length joined together side by side, was the prototype of the modern organ. Ctesibius, a barber of Alexandria, 200 B. C., placed valves inside a wind chest; under each pipe he cut off the wind and operated it by levers.

Historical References.—About 670 A. D. organs began to be used in churches in Western Europe. One in the Winchester Cathedral in 951 had 26 pairs of bellows. In the fourteenth century the keys were made small, to be played with the fingers, and the compass was thereby increased to three octaves, and in the sixteenth century to four. About 1470, pipes were made 16 to 32 feet long, and later on reed pipes were invented to imitate the tones of other instruments. In 1712 the "swell box" was added. Since then organs have been improved by the voicing of pipes to improve the tone. Electrical and water motors are used in all large instruments, and pneumatic and electrical actions have enabled the operator to place the keyboard wherever the organist desires.

The First Organ.—The first organ built in the United States was made by John Clark at Salem, Mass., in 1743. The first organ builder was William M. Goodrich, of Boston, Mass., who established the industry in 1805.

The Reed Organ.—Reed organs are of great antiquity, but since 1890 their manufacture has declined.

Melodeons. — Up to 1835 nearly all melodeons used in the United States were imported from France. In 1846 J. Cahart, of New York, perfected the suction method, but they gradually fell into disuse.

Self-Playing Organs.—The essential feature of such instruments is the perforated music sheet, a French invention of 1842, patented in the United States in 1849. Since 1890 a number of companies in Connecticut have made a series of improvements that have raised self-players, pianos as well as organs, into the class of true musical instruments. Music-boxes are an important element in the trade, but scant attention is given them, as they are not an American product, though American ingenuity may yet address itself to the production of these agreeable companions of a leisure hour.

American Instruments.—It is a demonstrated fact that American-made instruments in which wood plays a part have a greater power of resistance against climatic effects than imported instruments can ever possess. The instruments which engage most attention of manufacturers outside of pianos and organs are mandolins, guitars, violins and banjos.

Comparative Summary of Musical Instrument Industry, Pianos and Materials.

	1880	1890	1900
Number of establishments...	174	236	261
Capital invested	$9,869,577	$18,430,872	$38,790,494
Wage-earners	6,575	12,432	17,869
Wages paid..................	$4.663,193	$8,369,347	$9,818,996
Value of product............	$12,264,521	$25,766,368	$35,324,090

Comparative Summary of Musical Instrument Industry, Organs and Materials.

	1880	1890	1900
Number of Establishments..	171	145	139
Capital Invested...........	$3,922,338	$9,890,288	$5,011,987
Wage Earners..............	4,202	4.608	3,453
Wages Paid.................	$2,142,539	$2,674,191	$1,720,727
Value of Product..........	$6,136,472	$9,213,188	$5,691,504

The American people are in many respects leading the world in music, though the inspiration comes from the German master minds of music, who find here a most cordial welcome and a deep appreciation of musical genius.

Needle and Pin Industries.

Early Needles.—Excellent specimens of needles are still occasionally found near the sites of the ancient lake dwellings in Central Europe, made of fish bone, horse bone and bronze. Needles made of bronze are found in Egyptian and Scandinavian tombs, varying in length from 2½ to 8 inches. Steel needles were introduced into Europe by the Moors at the time of the Saracen invasion, but needles were used in China from time immemorial. In 1370 steel needles were made in Nuremburg, Germany, and in 1543 they were made in London. In 1650 the industry was established in Buckinghamshire, where it still thrives to this day.

Origin of the Industry in America.—In 1766 needles were made in Lynn, Mass., of imported drawn wire, and in 1775 Jeremiah Wilkinson made needles of hand-drawn wire. In 1826 drill-eye needles were made; in 1840 they were hardened in oil instead of water. Automatic machines for simplifying work soon followed. The industry was not firmly established until 1852, when a demand arose for needles in various kinds of machinery. Sewing-machine and knitting-machine needles were soon after manufactured in large quantities. In addition to the household sewing-machine needle there are various others made, such as are used in sewing leather, cloth, hosiery, etc. The machinery used in their manufacture represents a very high type of mechanical ingenuity in which hand labor is reduced to a minimum.

Pins.—Pins made of bone, ivory, bronze, copper and iron are found in ancient ruins, and in one locality in Switzerland 10,000 pins were found at one unearthing, ornamental, curious and beautiful, and larger than those now in use, some resembled the modern safety pin. The early Anglo-Saxon and Britons used ribbons, loop holes, clasps, hooks and eyes and skewers of wood, bone, brass and silver or gold for fastening.

Pins in Early Times.—Brass pins were first made in England in 1626 by John Tilsby, and soon after shops multiplied. Early last century William Bundy invented what is practically the modern process of pin making. In 1817 Seth Hunt made head, shaft and point from one piece. In 1824 W. L. Wright, of New Hampshire, invented a machine which revolutionized pin making and greatly stimulated the industry. During the Revolutionary War pins were supplied from Connecticut and the Carolinas in a limited way. English pin makers then came to New York, and by employing machinery and convict labor soon placed them within reach of all. Automatic machines appeared after 1830, which made from 60 to 70 per minute. Invention followed invention, each superseding previously-made machines.

Modern Pins.—The modern pins are made by improved Atwood or Fowler machines, into which are fed coils of wire and cut into desired lengths and headed. The machinery is intricate but works with exactitude and at enormous speed. Various machines have been brought into use which stick 600 packages a day and upward.

Process of Manufacture.—The processes through which a sewing machine needle passes in its manufacture are as follows: Blank piece of wire, reduced blank, reduced and pointed blank, eye punched, hardened and tempered, hard burr dressed, brass burnished, eye polished, first inspection, hard straightened, finish pointed, and finished.

The ordinary machine needles are made of crucible steel wire in coils, which are straightened by automatic machines, fed into a machine which forms the large end of the needle, then cut into proper lengths, next roughed, dressed and smoothed three at a time in special coarse with fine emery machines; next the evenly smoothed needles are tapered; next another machine makes two grooves, one on each side, by two fine circular saws. A belt-driven punching machine punches the eye. The needles are then automatically passed into a reverbatory furnace where they are heated to a cherry red and then immersed in whale oil, and next tempered in sheet-iron pans suspended from the arms of a revolving shaft. They are then held by the hands of the operators in bunches of 20 and rotated against emery cloth to be cleaned; after this the grooves are polished by being held, 70 at a time, against a scratch brush or bristle brush of brass wire revolving 8,000 times a minute.

The eye was next polished by being threaded in gangs with cotton thread, drawn back and forth in various slanting positions so that the polishing powder would act on all parts of the eye.

The needles are then subjected to one more cleaning process with a revolving hair brush. The final operations are the finishing of the point, which are done on a fine emery wheel and with a revolving hair brush with crocus and alcohol.

A Second Method.—There is a second method of manufacturing needles in which the blanks are placed in a hopper, after which their ends are compressed and drawn out to form blades.

Common Pins.—Making pins from wire and forming the heads out of cut sections was begun in a sort of way as far back as 1817 and received a stimulus in 1824. It has, however, been only in recent years that machines have been invented adapted for extremely rapidly cutting of coils of wire into lengths and pointing and heading the pins, and sticking them into the papers, that has placed this industry where it is. Many tons of pins are made in the United States weekly, and it is said that the daily production amounts to some twenty-five million pins.

In one form or another pins are of the highest antiquity, and it may be assumed that their use is coeval with human dress of any kind, the earliest form doubtless being a natural thorn, such as is still often seen fastening the dresses of peasant women in Upper Egypt. Pins of bronze, and bronze brooches in which the pin is an essential feature, have been dug up among the remains of the bronze age. An English act of Parliament (1540) provided that pins should be made with heads well soldered on. They were then made of brass or iron.

In pin making, coils of steel wire are placed upon a reel, from whence the wire is drawn automatically by a pair of pincers between fixed studs that strengthen it. A pin length is then seized by a pair of lateral jaws, from which a portion of the wire is left projecting, when a snap-head die advances and partially shapes the head. The blank is released and pushed forward about one-twentieth of an inch, when it is given another squeeze by the same die. By this repetition of motion the head is completed and the blank is cut off the wire in the length desired. About one-eighth of an inch of wire is required to make a pin.

These blanks drop into a slot just wide enough to let the shank of the pin fall through, so that the pins are suspended by their necks as they slide down the slot. They are seized and rotated as they move in front of a cylindrical cutter with sharp grooves on its surface that points the pins. They are then thrown from the machine properly shaped, and if made of brass are cleaned by being boiled in weak, sour beer, then cleaned and coated with tin by placing them alternately between layers of pins and grain tin in a copper can to which water is added along with bitartrate of potash.

Heat is applied to this solution which deposits tin on the surface of the pins, which are then revolved in a barrel of bran or sawdust for cleansing.

Papering.—The papering process then follows, which is accomplished by an automatic machine in the following manner: The pins to be stuck are placed in a hopper, in connection with a steel plate with longitudinal slits corresponding to the number of pins which form a row in the paper. The pins in the hopper are stirred up by a comb-like tool, the shanks drop through the slits in this steel plate and the pins are suspended by their heads. Long, narrow sheets of paper are presented by the operator to the action of the machine by which two raised folds are crimped and the row of pins collected in the slit-steel plate is then, by being subjected to the same action, pressed through the crimped folds. These operations are repeated until the requisite rows of pins are stuck in each paper.

Comparative View of Production.

	1880	1890	1900
Number of establishments..	40	45	43
Capital invested............	$1,144,550	$1,820,089	$3,235,158
Wage-earners	1,077	1,609	2,353
Wages paid	$392,214	$649,484	$939,846
Value of products...........	$1,378,023	$1,515,865	$2,738,439

The product for 1900 was 1,397,532 gross of needles and 68,889,260 gross of pins, or practically two-thirds of a gross of pins for every individual in the United States. Total value of needles and pins in that year $2,462,745.

Notwithstanding the heavy home production, importations of all kinds of needles increased from $358,838 in 1891 to $418,004 in 1900.

Nets and Seines.

Uses.—The catching of fish early led to the making, in a crude way and by crude devices, of seines and nets. The evidences of these early devices indicate in some essential features practically as much skill as is shown to-day, though there is an absence of finish and regularity which is observable in the work of to-day. One edge of the net is often provided with sinkers and the other with floats. It hangs vertically in the water, and when its ends are brought together or drawn ashore, holds the entrapped fish. A net is usually a fabric of twine or thread or other material, in some cases woven or worked into meshes, and used for catching fish, birds or butterflies.

Net and Seine Devices.—In coast fishing, as in the menhaden industry, the appliances are of net or seine construction, but of greater proportions; and frequently, when spread in circular form, are 100 yards in diameter. They are supported on the surface of the water by cork and wood at frequent intervals. In some localities along the coasts of the United States and in some of the larger rivers, other somewhat similar devices are profitably employed to catch fish in large quantities, and which constitute the basis of an industry of rapidly growing importance. At the present time upward of 1,000 men are engaged in the manufacture of nets and seines, producing goods of an annual value in excess of $1,500,000.

Art of Mending Nets.—The art of mending nets is not understood by all fishermen. There are 100 persons who can make nets for one that can repair. The important thing to know is to be able to make a bent knot. The ordinary netting stitch is useless. The first operation is to spread the net out as flatly as possible, with the loops in the same position with regard to the mender as they were to the netter when the net was made. The damaged part must be cut away in regular rows. The process is tedious and demands patience and natural skill. The production of nets for the various fishing requirements has developed special skill and by the use of particularly strong material the quality of workmanship has reached a high order of excellence.

Oilcloth Industry.

Composition.—Oilcloth consists generally of a coarse canvas, usually of jute or burlap, coated on both sides and partly saturated with thick oil paint, and usually having a colored pattern printed on it. The raw material of oilcloth consists of burlap, cotton sheeting, drill and duck, with which are used linseed oil, pigments, varnishes and cork. The usual process of manufacturing is to draw the canvas through troughs filled with liquid glue, rye flour, tapioca or varnish in differing proportions. This surplus sizing is squeezed out between rollers, then rubbed with pumice stone by hand or with steam rollers. The cloth is then coated with paint of ochre, benzine and linseed oil and next evened down by being passed through a series of metal blades. Painting and cribbing is repeated according to the quality of cloth desired.

Patterns.—Patterns are carved on wooden blocks, made of pine and faced with hard wood, using a separate block for each color. The design is carved in relief on each block. The various colors are applied by rollers, which take up the coloring matter from the troughs. The printing of the cloth is done by machinery, the cloth passing over a table under the blocks, which have a rising and falling motion. After drying, the cloth is varnished, trimmed and rolled. What are called pin blocks are often used instead, which are three layers of wood firmly cemented together. The surface block is divided up by sawing it in lines very close together and at right angles, constituting a series of pegs. Such pegs as are not needed for outlining are cut away and the blocks are then ready for use.

Comparative Summary of the Oil Cloth Industry (Floor Cloth).

	18 0	1890	1900
Number of establishments...	25	19	18
Capital invested............	$3,429,550	$3,704,436	$7,176,198
Wage-earners...............	1,735	1,521	2,718
Wages paid.................	$733,235	$745.766	$,327.235
Value of products..........	$1,752,587	$3,877,822	$7,807,105

The production of enameled oilcloth is at present confined to 9 large establishments, employing 512 workmen, representing an invested capital of $1,702,904 and products valued at $3,595,515.

The doubling of demand for oilcloth in the past decade is due to its quite general substitution in modern offices and to a large extent in private dwellings in place and in preference to carpeting because of greater cleanliness and greater ease in cleaning.

Oil Industry, The.

Classifications of Oils.—Next to coal, oil is the most important member of the mineral family in its relation to human needs and progress. Oil has been defined as any one of a great variety of unctuous combustible substances which do not mix with water and may be divided into three general classes—animal, vegetable and mineral. They are used as foods, solvents for lubrication, illumination and for the generation of power. They are also used as raw material in many industries. The vegetable oils are of two classes—essential oils and natural oils:

Essential Oils.—There are 124 establishments in the United States making essential oils. They are volatile oils, and exist in ready form in animals and vegetable organisms; they are called essential because they possess in a concentrated form certain of the characteristic properties of the plants from which they are derived. They are also known as volatile oils and as distilled oils. These oils are recovered by several different processes, depending upon the nature of the plant and the nature of the oil. The plants from which the oils are obtained, when in full bloom, usually during August and September, are partially dried, placed in large wooden casks and closed with steel-tight covers. The steam enters the bottom of the vat and expands the globules of oil contained in the cells, which burst. Being charged with the essential oil it goes through the top of the vat and passes to a receiver, where it is collected and dipped off.

The Vegetable Oils.—Most of the natural oil, and, in fact, all animal oil, consists of what is termed the ethereal salts of glycerine with a number of organic acids, principally stearine, oleic and palmytic, which form respectively stearine, oleine and palmatin. Mutton tallow, beef tallow and lard are rich in stearine; human fat and palm oil in palmatin, and sperm and col liver oil in olein.

Animal Oils.—Animal oils are obtained by the distillation of bones. The vegetables and animal oils containing oxygen are mostly glycerides of fatty acid; the mineral oils and many of the volatile oils of vegetable origin are simply compounds of carbon and hydrogen. The larger proportion of vegetable and animal oils contains oxygen in addition; some oils contain nitrogen and sulphur, as the oil of mustard.

Fixed Oils.—The fixed oils used in painting are largely made of linseed, walnut and poppy. The essential oils used in painting are those of turpentine for diluting the pigments ground in oil.

Petroleum.—Petroleum is a complex mixture of various hydro carbons and varies very much in composition and properties. It is refined by distillation, and the products include kerosene, benzine, gasoline, paraffine, etc. Petroleum spirit is a volatile liquid contained in the distillation of crude petroleum at 170 degrees Fahr. or below.

Importance of Petroleum.—As an oil, petroleum has exerted a greater influence upon the world in its progress than any other known product, unless we except gold and steel, the influences of which are due to radically different causes and reasons. As an industrial product, petroleum is without an equal as a generator of activities in industrial channels. Too much is known of this valuable product to warrant any detailed consideration of it.

First Commercial Discovery.—The first great deposit in the United States was discovered in the Allegheny River Valley upwards of one hundred miles north of Pittsburgh. Subsequent discoveries of bigger magnitude in Texas and California, and the discovery of lesser beds in West Virginia, Ohio, Kentucky, Indiana, Missouri, Kansas, Colorado and other States, resulted in the great development of one of the largest industries on the American continent and gave rise to a commercial organization which has taught the world new lessons in industrial and financial management.

Distribution.—The distribution of petroleum after refining has developed an enormous amount of traffic which is a source of considerable revenue to the railway system of the United States and to the shipping industry. The production of oil has also developed and aided a number of associated industries, among which may be mentioned iron and steel, cooperage and a long line of minor industries which find life and vitality in furnishing accessories for the conduct of this great business.

Refining.—The refining of oil for illumination purposes has been perfected to the highest possible degree of efficiency, and a separate industry has sprung up which furnishes employment to vast capital and engages some of the brightest commercial talent in the country. The methods of refining are well understood and are conducted upon a scale of great magnitude, resulting in a cheapening of cost, which brings this valuable product within the easy reach of vast numbers of people.

Fuel Oils.—The development of the oil beds of Texas and California has resulted in the adoption of these oils as fuels, and they are found to be very economical, occupying less space, costing less money and more available than coal. Some manufacturing industries have welcomed this fuel as a welcome escape from coal, and the transformation now going on from coal to oil is destined to result in revolutionary methods in use of fuel. The extent of these deposits is unknown, and though not unknowable, enterprise is at work seeking in all sections of the country where oil presumably exists for indications of its existence.

Finer Oil Products.—It is in the finer oils, however, that special interest is found. A long array of vegetable products is brought into the service to furnish oils for the multiplied uses for which they are available. We have cottonseed oil, one of the most important oils produced from the commercial standpoint. Castor oils, resinous drying oils, essential oils by the score, linseed oils, of great value in painting and other work; menhaden oil, valuable for fertilization and tanning; musk oil, valuable as a drug; neatsfoot oil, an excellent household remedy; olive oil, a table condiment; palm oils, paper oils, perfumery oils, seal oil, rosin oil, sperm oil, oil of turpentine, whale oil, and a vast variety beyond the limits of convenient mention.

Bone oil is obtained when bone black or animal charcoal is made by the ignition of bones in iron cylinders; camphor oil, from the incisions in the wood of the camphor tree of Borneo and Sumatra; cocoanut oil, from the cocoanut, extracted by hydraulic pressure; cod-liver oil, from the liver of cod; castor oil is expressed from the seeds of the Mexican oil bush, which are crushed in hempen bags by hydraulic pressure; the common castor oil is prepared by gently heating the crushed seeds and pressing them while hot; croton oil is made from the shelled seeds of molucca grains imported from the East Indies.

The preparation of essential oils is intricate. They are, of course, obtained by distillation. The odor of some flowers is too delicate to bear heat, and for these, the process of absorption is employed. Sheets of glass on wooden frames called chassis are coated on their upper and under surfaces with grease about a tenth of an inch thick. The flowers are spread on this grease, with frames piled one on the other, where they remain one or two days, when fresh flowers are placed on them. This process impregnates the fat with the odors after this process is continued two or three months. Paraffine, glycerine or vaseline is used. The grease is then removed and the oil is extracted with alcohol. The essential oils of lemons and oranges are largely obtained by expressing them from the rinds by powerful pressure. All flowers with very delicate perfume, which would be destroyed by distillation, are so treated.

Rectification is done by heat and without water, and the flowers are subjected to this heat as short a time as possible. Fusel oils are a mixture of various alcohols obtained in the manufacture of alcohol from grain or potatoes. Lard oil is the oil of the pig melted by a gentle heat and strained through flannel or a hair sieve. Linseed oil is obtained by expressing the seeds of flax, which yield from 20 to 25 per cent. of their weight. Boiled linseed oil, which has greater drying qualities, is made by boiling with some litharge, sugar of lead or white vitriol. Musk oil is obtained from the grain musk, ambergris and oil of lavender. Neatsfoot oil comes from ox or cow heels and tripe by boiling them in water and skimming off the oil. Olive oil, from the common olive, which is sometimes mixed with cottonseed oil and sesame oils. Palm oil is obtained from several species of palm. The nuts or fruit are allowed to decompose in the open air, and are then reduced to pulp and mixed with water and heated. Perfumery oils are obtained from almonds or olives, to which essential oil is frequently added until agreeably fragrant, allowed to settle and then decanted.

Piney oil is gathered from the seed of the piney tree; poppy-seed oil, from the opium poppy found in Asia. Seal oil is from the blubber of the hooded seal and harp seal and other kinds; rosin oil, from the distillation of resin; sharks'-liver oil, from the liver of sharks, yielding from 15 to 60 gallons each; sperm oil, from the head matter of the sperm whale, now chiefly found in the Southern Ocean, and useful for lamps and machinery. Farrier's oil (spike oil) is made of oil of turpentine, Barbados tar and alkenet root, digested together for a week. The oil of turpentine of commerce is made by distilling strained American turpentine along with water, the product in oil varying from 14 to 16 per cent., which may be rectified by redistillation. Watchmakers' oil is made by putting a strip of lead in a white glass bottle filled with pure almond or olive oil, and exposing it to the sun's rays until the curdy matter ceases to be deposited.

Comparative Summary of the Essential Oil Industry.

	1880	1890	1900
Number of establishments...	124	67	70
Capital invested............	$67,757	$152.223	$612,657
Wage-earners................	278	197	199
Wages paid..................	$24,030	$28,924	$69,500
Value of products...........	$248,858	$255,847	$850,093

Oleomargarine Making.

Method of Making.—Practically all the oleomargarine manufactured in the United States is made by the simple process of churning a melted mixture of oleo oil and neutral lard with milk, cream or melted butter, to give it a butter flavor, and coloring matter to give it any desired shade of yellow, in semblance to butter. In the cheap grades cotton-seed oil is often substituted, but never to the exclusion of oleo oil and neutral lard. After churning, the product is salted and put upon the market in various forms.

Grades.—A high grade of oleomargarine is made of 100 pounds oleo oil, 130 pounds neutral lard, 95 pounds butter, 32 pounds salt, ½ pound of suitable color, making in all 357½ pounds.

A cheap grade is made of 495 pounds oleo oil, 265 pounds neutral lard, 315 pounds cotton-seed oil, 255 pounds milk, 120 pounds salt and 1¼ pounds of color; total, 1,451¼ pounds, which produce from 1,265 to 1,300 pounds of oleomargarine.

Equipment.—The equipment of an oleomargarine factory consists mainly of the machinery of power, melting tanks, mixing tanks, milk receptacles, churns and machine butter workers. The number and character of ingredients of oleomargarine make it susceptible of an infinite number of combinations, and each manufacturer has his own working formula. Very much depends on the handling of the oils and the regulation of temperatures at each succeeding step.

Oleo Oil.—Oleo oil is obtained from beef fat by the processes of settling, crystallization and pressure, which separate it from the stearine and the fibre. The number of grades manufactured is from three to five. The oil made from sheep fat cannot be neutralized, but retains its characteristic odor. The inferior product is exported to Europe. While there is no substantial uniformity in the process of manufacturing, there is great diversity in the grades and combinations of material used. The low-grade oils may be manufactured from scrap fat and the addition of stearine, so that it will hold a greater proportion of cotton-seed oil.

Comparative Summary of the Oleomargarine Industry.

	1880	1860	1900
Number of establishments	15	12	24
Capital invested	$1,680,330	$634,542	$3,023,646
Wage-earners	599	264	1,084
Wages paid	$212,952	$154,138	$534,444
Value of products	$6,892,939	$2,988,525	$12,499,812

Opticians and Optical Goods.

The somewhat artificial conditions of modern life are responsible for much of the activity of the optician. The eye, the most delicate and complex organ in the body, is, by reason of its important functions, as the king of the five senses, constantly under daily strain to carry impressions to the brain. That it should be frequently overtaxed is not surprising, when the conditions and exactions of modern life are regarded.

Optics has to do with light and vision. The science is divided by modern scholars into these subdivisions: Sources of light; transmission, velocity and intensity of light; reflection of light, as by mirrors; single refraction, as by lenses; dispersion and achromatism; optical instruments; the eye as an optical instrument; phosphorescence and fluorescence; double refraction, interference and polarization.

The human eye is placed in a bony cavity called the orbit, and is further protected by the fatty cushion within which it rests as well as by the brows, eyelids and eyelashes. Other appendages are the tear glands and the sac connected with it and other glands where secretions lubricate the eyelids and the eye itself, the numerous muscles which direct its range and the nerves and blood vessels which supply it. The human eye has a globe with the segment of a smaller globe planted on its anterior aspect; its anterio-posterior diameter is one inch, its traverse diameter slightly less. The larger sphere has about five-sixths of the whole surface. The two eyes have their axis almost parallel, excepting that in looking at near objects they decidedly converge. The point of meeting is the focus of vision, and, in order to avoid strain, great care should be taken to have it true, when the eye is used for any length of time. The adaptation of lenses to compensate for defective vision now engages the study and skill of a large number of experts.

The Microscope.—Just as the telescope reveals the infinity of the universe so does the microscope reveal the infinity of the hidden world beyond the power of human vision. The origin of the telescope is unknown. The microscope was used by the Chinese, Japanese, Assyrians and Egyptians. The microscope is made either single or compound. In the single, the object is viewed directly; in the compound the image formed by one lens is magnified by the other. It was invented in 1624 and improved by a score of scientific men who have become known as the fathers of microscopy.

Microscopic Uses.—The microscope brings within range of human vision the wonders of the unseen world. It has led to the development of new sciences and added much to the stock of human knowledge. Biology and botany owe much to it; medicine owes more. It is the constant companion of the jeweler, engraver, the miner, the chemist and a score of others engaged in industrial pursuits.

The Compound Objective.—An important feature was the improvement of Lister in 1829, who introduced the aplantic foci and compound objective. The aplanic focus of a lens is the point or focus from which rays diverging pass the lens without spherical aberration. In certain forms of lenses there are two such foci, and it is by taking advantage of this fact that the best adapted aplanatic object glasses of microscopes are constructed.

The Lens.—The term lens is said to be derived from resemblance to the seed of a lentil, which is like a double convex lens. The glass is so shaped as to afford two regular opposite surfaces, both curved, or one curved and the other plain, which changes the direction of the rays of light and diminish or increase the apparent size of the objects viewed through it. Combinations of lenses increase this effect. The curved surfaces are usually spherical. The ordinary lenses of this description are of six varieties, viz., plano, concave, double concave, plano-convex, double convex, meniscus and concave-convex. Besides, there are many other shapes, peculiar from their proportions, construction, arrangement or specific effects.

Polarization.—The polarization of light is an interesting branch of optical science, if it may be so-called. Polarization was discovered by reflection from polished surfaces as far back as 1808. Colored polarization was discovered in 1811. The kaleidoscope was invented in 1814, and the reflecting stereoscope in 1838. One of the more recent developments in optics is the Fiske range finder, which enables a gunner to direct his cannon upon a target when its distance is unknown or obscured by fog. Another improvement is the solarometer which has for its object the determining of the position for the compass error of a ship at sea when the horizon is darkened. A still more interesting development is that which is effected through the magic lantern and the production of reflections upon the screen. The principle of moving pictures is due to persistence of vision. (See Moving Pictures, opp. col.)

Anatomy of the Eye.—The principle on which the eye is constructed is that of the camera obscura, a dark chamber with a small opening for the admission of light, a quantity of black matter to absorb the superabundant rays and a nervous expansion on that wall which receives the rays of light. The globe consists of the retina, refracting media, a tunic inclosing them, the cornea and the choroid membrane. The vitreous humor forms four-fifths of the globe. The crystalline lens is of three parts or layers, consisting of hundreds of smaller concentric layers. The eyeball is composed of segments of two spheres of different sizes, and has three investing tunics and three refracting media. The eye is served with numerous muscles of delicate structure acting in unison.

The eye is invested by three coats, first the sclerotic, a white, tough, fibrous substance, "the white of the eye," visible through the delicate conjunctiva which lines the orbit and is reflected over the sclerotic and the cornea. Inwardly it is brown. The muscles are attached to it, and through a sieve-like process, the cribriform lamina, it transmits the filaments of the optic and other nerves and blood-vessels. The anterior one-sixth of the eye surface is occupied by the cornea, which is a concavo-convex lens, projecting, transparent, and in intimate structure resembling the sclerotica. It is composed of more than 60 lamina. the innermost and outermost of which are highly elastic. The posterior layer is lined by a "pavement" epithelium of polygonal cells. The cornea is well supplied with nerves which are called ciliary nerves. The second coat of the eye is composed of the choroid tunic, the iris, the ciliary processes, muscle and ligament. The third coat of the eye is the retina. Without is the choroid, within the vitreous humor. The contents of the eye are the aqueous humor, the crystalline lens and the vitreous humor. The aqueous humor consists of about four or five grains of water with a very small proportion of common salt and other matters in solution. It occupies the space between the cornea in front and the crystalline lens behind. This lens brings the rays of light which fall upon it to a focus and forms an image upon the retina, the transmission of which to the brain produces sight.

Moving Pictures.—The rapid presentation of the same object in motion, presenting these different positions to the eye in detached views, causes the figure to constantly move. To secure the best results the ribbon with its views should remain with a figure as long as possible between the light and the lens, and the shifting to the next view should be as nearly instantaneous as possible.

How It Works.—The action of the device is as follows: An electric motor drives a countershaft, and through a worm gear another shaft parallel to it, bearing a sprocket pulley, whose teeth penetrate little marginal holes in the ribbon containing the views, draws it down from the reel above, and delivers it to the receiving reel opposite. There is a revolving crank-pin or spool on the end of the countershaft which beats down the ribbon of views, making the ribbon pass forward through guides in front of the lens by a succession of jerks. This holds each view before the lens an instant, and the ribbon is jerked rapidly along.

The Spectroscope.—The spectroscope is one of the products of the development of the science of optics through which a vast amount of knowledge has been made known to the world. The spectroscope has been applied in astronomy, in the laboratory, and in many branches of industry as well as in metallurgy, and it has been found to serve most valuable purposes. By use of the spectroscope hitherto unknown metals have been discovered and their distinctiveness established.

The Distance Seer.—Among the promised wonders of the age is the "distance seer," or teleetroscope, by which it may be possible to see at long distances over electric wires just as they are now used for telephonic and telegraphic purposes. The science of optics has in store many wonders, truths and principles yet to be developed, and through which the sum total knowledge of the human family will be very greatly increased.

Comparative Summary of the Optical Goods Industry.

	1880	1890	1900
Number of establishments...	62	190	350
Capital invested............	$643,825	$2,608,176	$5,567,809
Wage-earners................	1,088	2,507	4,341
Wages paid..................	$450,897	$1,010,374	$1,935,219
Value of products...........	$1,182,142	$3,505,973	$7,790,970

Packing Box Industry.

Center of the Industry.—Among those industries which are of considerable magnitude, but which attract very little attention, is the industry of making wooden packing boxes. This industry is largely centered in and near the larger commercial centers from whence supplies can be quickly and cheaply delivered to the jobbing houses handling all manner of merchandise for shipment over the United States to retail storekeepers and abroad. The bulk of the material used is known as North Carolina pine or short-leafed pine, which belongs to the yellow pine family, but is less dense and less valuable. It is also largely used in house construction for flooring, partitions and for various other ordinary purposes. It is a comparatively soft, easily-sawed lumber and is preferably used for box making as it is cheap and the lumber, after serving its first use, is regarded as waste, being frequently knotty.

Material.—This lumber is roughly worked up into boxes of prescribed dimensions to suit the widths or size of material to be boxed, and it forms mainly the material used for packing and shipping drygoods, hardware, etc.

Statistics.—The activity of the industry indicates with a fair degree of accuracy the activity in commercial circles, both wholesale and retail. The accompanying figures indicate its extent and volume:

Comparative Statement of the Wooden Packing Box Industry.

	1880	1890	1900
Number of establishments ..	602	6 6	896
Capital invested............	$5,304,212	$13,018,456	$21,952,757
Wage-workers	7,772	13,006	22,034
Wages paid	$2,769,135	$5,615,707	$7,827,955
Value of products...........	$12,687,068	$25,513,180	$38,216,384

Painting and Painters.

Painters as Artists.—The early painters were a highly favored class of craftsmen. The historians and early writers always spoke well of the painter and admired and commended his work. He was an artist as well as a craftsman, but unfortunately the ravages of time and war and air and sunlight have left very little visible to-day to chronicle his achievements. The painters had their guilds in Europe, and they constituted practically a separate class of workmen; they had their high ideals and their pride, and were well justified in holding them.

Classes of Painters.—Painters have been divided into four grades—the historic painter, the landscape painter, the portrait and marine painter and the painter connected with the mechanical arts; it is the latter with which we have to deal.

Business of the Painter.—The business of the painter is twofold—to beautify and to preserve. To this end he has placed at his command a great variety of material. Ordinarily the first duty of the painter is to see that the surface for the reception of paint is clean. The first process for certain classes of work is that of priming, which consists in giving a coat of whitelead with redlead and a little drier and linseed oil; a second coat is then given, consisting of whitelead and linseed oil; the flattening coat follows, the object of which is to do away with the gloss or glaze of the oil by obtaining a flat appearance. Flattening must be executed quickly, on account of the evaporation of the turpentine. Flatted work is generally done only where very fine work is desired. All new outside work should be primed with redlead and litharge mixed in linseed oil.

Graining.—Graining is the imitation of several species of ornamental wood, such as satin-wood, rosewood, mahogany, oak and others. Camel's-hair pencils are much used. Imitation wainscot requires the use of combs of various degrees of fineness to obtain the grain desired. When dry, it is over-grained to obtain a more complete representation of the natural wood, and is then varnished. Marbling is the imitation of real marble, granites, etc., represented by splashing, which should be painted and rubbed and polished to obtain an even surface.

Ornamental Painting. — Ornamental painting embraces the execution of friezes and the decorative parts of architecture on walls and ceilings. The ground is well prepared and of the tint of the proposed work. The ornaments and figures are drawn upon it, and are then painted and shaded to give them their due effect. When the ornamental work is of a similar pattern throughout, it is effected by stenciling; this method consists in drawing a certain length of the pattern on paper, which is pricked through with a large-sized needle, then laid on the wall to be ornamented and struck with a small linen bag containing powdered chalk.

Preferences.—Many of these methods of decoration have been styled "shams;" many prefer real woods and argue for the disuse of paints. This preference has led to an increased use of deals and pines for inside doors, wainscots, linings and shutters, which are often varnished and polished and create a very fine effect.

Materials Used.—The materials most commonly used for the production of paints and varnishes are whitelead, redlead, zinc white and oxide of iron. The vehicles used are water, oils and spirits of turpentine. The chief solvent is spirits of turpentine; for driers, litharge is used; acetate of lead, sulphate of zinc and binoxide of manganese, and redlead are among the materials used. Among the coloring pigments are ochres, lampblack, umber, sienna and many metallic salts.

Paint Mixing.—Prussian blue, much used for dark blues, making purples and intensifying black, is made by mixing prussiate of potash with a salt of iron. Chrome yellows are made by mixing dilute solutions of acetate of lead or nitrate of lead and bichromate of potash. Indian red is ground hematite ore from Bengal. "Lakes" are made by precipitating colored vegetable tinctures by means of alum and carbonate of potash. Greens may be made by mixing blue and yellow pigments, but they are less durable than those produced direct from copper, arsenic, etc. The composition of paints is governed by the nature of the material to be painted, kind of surface to be covered, nature and appearance of work to be done, the climate and degree of exposure to be encountered. Turpentine is to be avoided as much as possible, but it is good to prevent blistering. The quality of the material makes an important difference in the proportions used. Ordinary white paint is generally composed of whitelead, linseed oil, driers and spirits of turpentine. Colored lead paint is made by adding a pigment; the drier oxidizes the oil, the turpentine is a solvent, and the lead gives "body." Zinc paints have zinc for a base instead of whitelead, and do not so readily combine with oil. They retain color well, and when dry take polish.

Division of Colors.—Colors may be divided into common, such as grays, buffs and stone colors; fine, such as bright yellows, warm tints, cloud colors and common greens; delicate, such as blue verditer, pea greens, pinks, etc.

Pigments.—Pigments for common colors are as follows: For stone color, burnt or raw umber and yellow ochre; for buff, yellow ochre and Venetian red; for grays, lampblack, Indian red, Egyptian blue or French ultramarine and vermilion; for brown, burnt sienna, indigo lake, Prussian blue or indigo.

Fine Colors. — For fine colors the pigments which may be used are: For yellows, yellow chrome; for green, Prussian blue, chrome yellow, indigo, burnt sienna, but no arsenical greens; for salmon, Venetian red, vermilion; for fawn, stone ochre and vermilion; for delicate tints, sky blue, Prussian blue; for pea green, Brunswick green, French and Prussian blue and chrome yellow.

Special Paints.—Special paints are without number. A few may be mentioned: Inodorous, mixed without turpentine; non-poisonous, whitelead ground under pressure to increase density; Charlton white, white sulphide of zinc paint; alburine, a white enamel; oxide of iron paints, silicate oxide paint, titanic paint, enamel paint, silicate enamel paint, compo paint, liquid enamels, granite paints, bituminous paint, tar paint, asbestos paint, granulated cork paints and luminous paints.

Varnishes.—Varnish is a solution of resin in oil, turpentine or alcohol, in the production of which the oil dries and the other two solvents evaporate.

Kalsomining.—Kalsomining is a mixture of size and whiting or other pigment, and is sometimes termed fresco painting. True fresco painting consists in intimately intermingling coloring substances with the plaster while yet wet.

Tint Making.—To make tints add old rose, pink or lake to the white; to make gray, add celestial blue or rose pink to the white; for orange, add Dutch pink and lake to the white; for gray, add ultramarine and black to the white; for straw, add Dutch pink or yellow to the white.

Essential Qualities.—There is nothing better than linseed oil and pure whitelead for painting, with the introduction of lime; soap and water do not help. The essential qualities of good paints are that they should have a good body, will flow easily, will adhere to the surface without rising, and leave coats of equal thickness where the surfaces are inclined or even vertical. They must dry out and harden, and after hardening must be capable of adhering to the surface firmly. They must be durable, also.

Manufactured Colors. — Generally speaking, manufactured chemical colors do not answer well for outside work. Chrome yellows, chrome greens, Prussian blue and vermilions are fugitive, either singly or in combination. The ochres, stone yellow, Indian and Venetian reds, burnt and raw umbers and burnt and raw siennas are good and reliable colors.

Stain and Paint.—The difference between a stain and a paint proper lies in the presence or absence of a base. Paint is composed of a base with a vehicle, usually linseed oil or spirits of turpentine, and coloring pigment. In some cases coloring pigment answers as a base. A stain, having no base, lacks body.

What Painters Must Know.—Painters know, or are presumed to know, the properties of various colors and how to mix them to secure a desired result. There are three fundamental points to be kept in mind—namely, "complementary," "contrast," "harmony." The complementary of any primary color is a combination of the other two primaries. For instance, the complementary of red, equals yellow, plus blue equals green; blue equals red, plus yellow equals orange; yellow equals blue, plus red, equals purple.

Color Contrasts.—A contrast of color is simple or compound; thus, red forms a simple contrast to blue and green; a compound contrast to red is blue and yellow, which is green.

Careful Preparation.—Great care is essential in preparing a surface for paint. Rough places should be rubbed down with a block covered with sandpaper; knots and indications of sap should be varnished with white shellac varnish where the work is to be finished in light tints. In two-coat work the putty for covering nail-heads should be made of whitelead worked up with common whiting. When more than two coats are to be applied, the filling should be done between the first and second coats with ordinary pure linseed-oil putty.

Rules to Remember.—Never apply pure white as a priming coat. Each succeeding coat should be lighter than the preceding. No matter what the finish is to be, the first coat should be darker than the one which it precedes. If the work is to be finished in black, prime with black; if green, let that be the color of all the preceding coats; if blue, let that be the groundwork color.

Priming Applications.—Not half enough dark colors are used in priming applications. In imitating black walnut or other dark wood, use Venetian red finely ground in boiled oil, deeply stained with black. Dark colors make better foundations than whitelead or zinc. They dry harder and rub better and cost less. Finely ground French ochre is good for interior oak. For walls the first coat should be as dark as the shade, the object being to stain the plaster as much as possible. Glue should never be used in wall painting until after the second coat. Plaster mixed with weak glue size prevents its setting too rapidly.

Various Paints.—An economical paint is made of 2 quarts skim milk, 8 ounces fresh-slacked lime, 6 ounces linseed oil, 2 ounces white Burgundy pitch and 3 pounds Spanish white. The lime to be slacked in water, exposed to the air, and mixed in one-fourth the milk. Dissolve the pitch in oil, and add a little at a time; then add the rest of the milk and the Spanish white.

Luminous Paints.—There are some twenty different methods for making luminous paints, of which varnish is the basis, with linseed oil, barium sulphate, calcium sulphide, calcium carbonate and other materials used in varying proportions.

These paints are used on glass, on harness, porcelain, etc.

In mixing paints for out-door work, boiled oil is generally used, unless for the decorative part of the house. For in-door work use linseed oil, turpentine and a little drier, remembering that the less oil, the less gloss. The best driers are ground litharge and sugar of lead, the former for dark and middle tints, and the latter for light ones.

How Colors are Produced.—In mixing different colored paints to produce any desired tint, have the principal ingredient thick, and add to it the other thinner paints. The combination of colors to produce a desired tint are given below, noting that the first-named color is the principal ingredient and the others follow in the order of their importance. Of course, there are other formulæ for obtaining the desired tint, but this is both practical and popular, and will give satisfactory results:

Buff is produced by white, yellow ochre, red.

Copper is produced by red, yellow, black.

Chestnut is produced by red, black, yellow.

Drab is produced by white, yellow ochre, red, black.

Flesh is produced by white, yellow ochre, vermilion.

Freestone is produced by red, black, yellow ochre, white.

Gray is produced by white, lead, black.

Gold is produced by white, stone, ochre, red.

Green bronze is produced by chrome green, black, yellow.

Lemon is produced by white, chrome yellow.

Olive is produced by yellow, blue, black, white.

Orange is produced by yellow, red.

Peach is produced by white, vermilion.

Pearl is produced by white, black, blue.

Pink is produced by white, vermilion, lake.

Sandstone is produced by white, yellow ochre, black, red.

Snuff is produced by yellow, Van Dyke brown.

Violet is produced by red, blue, white.

A durable paint for out-door work is made of powdered charcoal ground in linseed oil, with sufficient litharge as a drier. Thin for use with boiled linseed oil.

The doubling of the output of paint factories in twenty years is indicative of a fair measure of industrial expansion. The industry has been greatly centralized through the employment of equipment capable of producing very large quantities at the same time, under the same roof. The preparation of ready-mixed paints has also greatly broadened the demand.

Comparative Summary of the Paint Industry.

	1880	1890	1900
Nnmber of establishments..	244	382	419
Capital invested............	$13,555,292	$34,009,203	$42,501,782
Wage-workers..............	4,483	7,044	8,151
Wages paid....... :..........	$2,132,255	$3,568,757	$3,929,787
Value of products	$23,390,767	$40,438,171	$50,874,995

Paper Bags, Boxes and Tubes.

Uses.—The manufacture of paper bags became a very important industry soon after the development of the West as a wheat-growing section, thirty or more years ago. A demand then arose for flour in smaller quantities than barrels, and to meet this demand paper bags were made, of material sufficiently heavy to hold the flour without waste or liability to break in transit. Since that time the use of paper bags has been extended into a great variety of uses, and the bag-making industry has correspondingly grown.

Making Inventions.—The stimulus which was given to the industry has led to the invention of numerous new devices and mechanical appliances, by which bags can be made faster and with improved bottoms. These inventions are all highly ingenuous and have brought great fortunes to their owners. This machinery turns out bags at an inconceivable speed, with scarcely any attendance, perfect in every detail, which, when made, are counted, packed, tied and made ready for shipment by automatic machinery. The paper-bag industry is one of the most interesting of the minor industries in point of equipment. The extraordinary demand has stimulated the erection of immense factories, which are equipped with the very best machinery that ingenuity can devise. Upward of 500 patents have been issued for square, satchel-bottom paper bags, from which the modern high-speed paper-bag machine has been developed. Upward of 500 patents have also been taken out for machines for making cell cases used as egg crates and many similar purposes. The strength of paper bags has been increased by various secret compositions which give to them a toughness and durability which make them safe and economic wrapping for a long list of domestic and commercial commodities.

Paper Tubes.—Quite a number of machines of especial design are now in use for making paper tubes, suitable for a great variety of purposes. Machines are also specially built to make fireworks tubes and tubes for general commercial use. In all these patents the tubes have a convolute wind, hence are made in short lengths only. There are machines for forming a continuous tubing by a spiral wind. Hundreds of valuable methods lie dormant in the Patent Office simply because some slightly more advantageous feature in construction supersedes them. The remarkable development of this industry has been assisted by the production of wood pulp at very low cost suitable for bags.

Paper Boxes.—The paper-box industry is a branch of the paper-bag industry, but is conducted separately. The value of these boxes has been enhanced by devices for strongly binding the corners, by which their life is prolonged and their contents protected. Commercial enterprise has extended the use of paper boxes twentyfold during the past twenty years. These boxes are used in scores of trades for the carrying of goods, such as drugs, confections, groceries, fruits, under and overwear, and an almost endless number of household and domestic articles.

Comparative Summary of the Paper Bag Industry.

	1880	1890	1900
Number of establishments..	80	56	63
Capital invested............	$1,304,700	$2,321,797	$6,900,291
Wage-earners	1,569	1,200	2,029
Wages paid...................	$439,620	$399,714	$683,783
Value of products	$4,112,566	$5,023,793	$7,359,975

Fancy Boxes. — One interesting and rapidly growing branch of the paper industry is that of what is termed fancy paper-box making. The boxing of vast quantities of merchandise, particularly those lines used for domestic and personal needs in small quantities, of which confections, soaps and many pharmaceutical preparations are examples, has developed into an enormous industry, and has increased the consumption for all such needs almost fourfold within twenty years.

Comparative Summary of the Fancy Box Industry.

	1880	1890	1900
Number of establishments...	369	588	729
Capital invested............	$2,496,496	$9,277,973	$14,979,305
Wage-earners.................	9,678	18,949	27,653
Wages paid....................	$2,373,948	$5,827,699	$8,151,625
Value of products...........	$7,665,553	$18,805,330	$27,316,317

The basis of the present enormous demand for paper boxes, bags and tubes is due to the custom and necessity imposed on trades people to present their commodities in small packages to suit the convenience of retail purchasers as well as to preserve the goods and have them available for quick delivery in compact and secure condition.

Paper Hanging Industry.

Papering as a Substitute for Tapestry.—Paper-hanging was first suggested as a substitute for tapestry hangings which it superseded. Tapestry was quite general for many centuries among the wealthier classes who could afford this expensive luxury. The inventive genius of mechanics was soon directed to the production of a paper for walls and ceilings, and their ingenuity was rewarded by rapidly extending requirements.

Introduction of Machinery.—With the introduction of machinery for paper making, an industry sprang into existence which has, within the past thirty years, become a most important one. Paper hangings are now manufactured which for exquisite design, artistic attractiveness and general merit, invite us to willingly forget the artistic tapestries of the mediæval ages.

Dados.—The high dados give a look of comfort to a home that is absent from the modern high-pitched room papered with one uniform pattern. The true theory of effect in papering is to use one or two bright colors in a room and to surround them by soft and subdued tints that bring up and do not destroy their brilliancy. A number of bright colors placed together destroy each other and leave but little impression upon the mind.

Growth of the Industry.—The industry has become quite an important one because of the universal custom among people in all stations of life to require papered walls and ceilings; the cost of papering has been reduced within the reach of all classes by reason of mechanical adaptations and the low price of raw material.

Designing.—The work of designing patterns is engaging the attention and study of an increasing number of workers who have developed high artistic conceptions of beauty and appropriateness. To them is due much credit for the effects produced on the interiors of dwellings and public buildings. Many designs represent a study of the past, and reproductions on paper of the architectural effects in past ages are highly creditable to modern skill.

Comparative Summary of the Paperhanging Industry.

	1880	1890	1900
Number of establishments...	25	27	51
Capital invested............	$3,560,500	$5,709,909	$8,889,794
Wage-earners................	2,487	2,584	4,172
Wages paid...	$874,921	$1,172,154	$2,074,138
Value of products..........	$6,267,303	$743,726	$10,663,209

Paper Makers and Paper Making.

Influence of Printing.—Paper making is coeval with earliest civilization. The schoolboy is familiar with the accounts of transforming the dried papyrus leaves into a condition to receive crude impressions to perpetuate primitive literature. The epochal event in paper making, printing, book making, binding and in modern civilization itself, was the discovery of the art of printing by Gutenberg. This discovery stimulated paper making suddenly, and methods were soon after found to supply the requirements of the early printers with paper, of which rags were the chief constituent. Ignorance of chemical solvents and of chemical reactions impeded the progress of paper making along what we now regard as scientific lines.

Modern Paper Making.—Paper making as developed to-day found its greatest impulse in the developments effected by chemists of a practical turn of mind, whose first pronounced victory was in the invention or discovery of a process of preparation by what is now known as the "digester," a most appropriate term, considering its functions and production.

The Fundamental Process. — The process of paper making finds a crude parallel in the human stomach, in which the spleen, heart and pancreas and liver take part. In fact, it might not be inappropriate to regard a paper mill as a huge stomach, but there the parallel ends. The various subsequent processes are similar in their nature to processes in many manufacturing establishments where properly prepared material is dealt out through suitable orifices into adapted mechanical appliances under pressure into desired thickness. Essentially, all paper is made in the same general way. Theoretically simple, the processes become quite complex, all having the same end in view, viz., the production of paper possessing varying qualities, according to the uses intended.

Epochal Events in Paper Making.—The epochal features of paper making may be divided appropriately into three — first, the utilization of the digester, involving chemicals for the reduction of material used in its component elements, preparatory re-formations into material for paper; second, the introduction of mechanical appliances in each separate branch, including water-power and steam-power; and third, the discovery of the utilization of timber, ground into fineness and transformed into pulp. From this was developed new and separate industries for the production of sulphite fibre and various other products constituting the last stage of the raw material for the manufacture of paper. Numerous minor steps necessary in these various processes have been developed by practice. There is a similarity in all, though inventive ingenuity has brought out many interesting devices for quick and economic production.

Early History.—The first paper mill in the United States was established near Germantown, Philadelphia, in the year 1693, where printing, writing and wrapping papers were manufactured. About 1728 a mill was erected on Chester Creek, Delaware County. This mill supplied the press of Benjamin Franklin and made the banknote paper used for Continental currency. The early paper-making industry owed an immense debt of gratitude to Benjamin Franklin and the early printers and bookmakers who made Philadelphia their headquarters. Their ingenuity, skill, energy and enterprise in bookmaking were remarkable, considering their restricted opportunities and the undeveloped conditions of the printing art at that day. Bookmakers to-day can learn from their work. Benjamin Franklin stated in 1787 that he had been interested in the establishment of eighteen paper mills, and that there were then as many as forty-eight paper mills in operation in Pennsylvania. In 1816 the first steam paper mill in the United States began operations in Pittsburg with an engine of sixteen horse-power and forty employés. As far back as 1728 a paper mill was built at Milton, Mass., seven miles from Boston. By 1776 three more had been established. The English automatic Fourdrinier machine, a revolutionizing machine in its time, came into existence in 1804 and was introduced into the United States in 1825 at Springfield, Mass. In 1850 automatic machinery was in use in all excepting two mills in that State.

Wood-Pulp Paper.—The first paper made in the United States of wood pulp was manufactured by Elzur Smith, of Lee, Mass., about 1855. Zenas Marshall Crane, in 1849, introduced silk threads into the fibre of banknote paper, to prevent counterfeiting. Four-fifths of all the loft-dried paper made between 1860 and 1897 was made in and near Springfield, Mass.

The Cylinder Machine.—It was John Ames who introduced a cylinder machine in 1822 that proved to be of great value to the industry, though the Fourdrinier subsequently superseded it. John Ames was a paper-machinery genius, and produced many valuable inventions. He originated the running of a continuous sheet through the size, instead of dropping each sheet. These inventions were first put into use at Chicopee Falls, Mass., under Ames. It was here, about 1849, that the first white paper to any extent was made.

Power.—The necessity of using water-power led to the gradual scattering of paper mills, and the Connecticut River offered this inducement. The first canal in the United States was built near Holyoke, Mass., in 1790. In 1830 a paper mill was erected there; then another in 1853, and since then mill after mill has been added, making Holyoke a great paper-making center.

Pulp Making.—The most important epoch was that of utilizing wood for paper making. At present no first-class paper plant feels safe without its forest. Majestic timber standing in a virgin forest this week may be transformed with suitable mixture into the perfumed billet-doux on the writing-desk of the lady of fashion next week, at least as to possibilities. This discovery wrought a revolution in paper making, reducing cost amazingly, and thereby vastly broadening the market.

Raw Material.—A promising feature of the paper industry to-day is the extension of the sources from which paper-making material may be economically derived. A score or more of new sources are now under process of exploitation from cotton hulls and rice refuse, to plant products of torrid and semi-torrid regions. Experiments are also being made under the investigations of chemists to utilize other than spruce timber, heretofore so largely depended upon because of its peculiar fitness and adaptability to chemical reagents.

Pulp Material.—Even yellow pine, because of its abundance, is being at present seriously experimented with, with reasonable prospects for adding that important timber to the list of available supplies. The forests of Canada, Maine and Northern New York afford the most available supplies at present, and within a few years paper mills of large capacity have been erected contiguous to these sources, so securing cheap water transportation for logs or cordwood.

Reformatory Effort. — Paper makers for the most part are engaged continuously, weekday and Sunday, because of the necessity of keeping the machinery constantly employed and to secure the economic advantage of the largest possible output in a given time. Within a recent period, agitations have been started with a view of reducing the time of daily employment from twelve to eight hours, by the employment of three "shifts" per twenty-four hours instead of two, a movement which, while having favorable humanitarian considerations, is unfavorably regarded by those whose interests are concerned in the observance of established methods.

"News" Paper.—The purposes to which paper is now put, as compared with twenty or forty years ago, are very greatly enlarged. The most important branch, perhaps, is that of "news" paper, which, since the perfection of the Hoe press, Bullock, and the Cottrell & Babcock press and other presses, is more generally manufactured into cylinders for easy handling and to avoid the delays incident to former methods of preparation. The remarkable achievement in the production of "news" paper is seen in its cost, which at times of over-supply has sold at 2 cents per pound, and in exceptional cases even lower. Pulp is largely used in its composition, but the liberal use of this material deprives the paper of power to indelibly retain impressions of type as long as paper made chiefly of rags and other more durable material.

Wrapping and Straw Board.—The wrapping paper branch and the straw-board branch are important in view of the volume of stock produced as well as for the very great variety turned out, from the heaviest paper for hardware wrapping down to the finest, approaching tissue grades in texture.

Book, Bond and Parchment.—The book, bond and parchment paper mills and the writing paper mills are the finest specimens of paper manufacturing equipment in the world. The methods for the production of excellence of quality and fineness of finish and for durability in retaining impressions, embody a multitude of minor inventions and improvements which have taxed the ingenuity and skill of some of the most expert designers and inventors on the American Continent. The numerous minor branches of the paper industry have been developed rapidly during the past decade by the substitution of better mechanical appliances.

The Fourdrinier Machine.—The Fourdrinier machine revolutionized paper making, prior to which paper making was conducted by hand. This machine was brought out by Louis Robert, of Essonnes, France, about the year 1798. The first step was to make a fluid stock, or pulp. This machine takes this pulp, screens it over an apron to a moving endless wire cloth made of closely woven, fine brass wire, and supported by small metal rolls set close, but not touching. This wire cloth keeps a uniform thickness of the pulp deposited. Transverse strength is given to this pulp by side "shakes," which cause the fibres to interlace, and thus give greater strength of texture. As the pulp is carried along the wire cloth, the water drains off; this moist web is then carried between couch rolls, which are covered with woolen felt, which pass it between press rolls and thence to driers. These driers are several large metal cylinders heated by steam. In these the drying process is completed, after which the paper is pressed between heavy metal rollers, and is then called calendered paper. It is then cut into desired sizes.

Wood Pulp.—The raw material of pulp is spruce and poplar. Balsam is now being tried, and experiments are being made with yellow pine.

Sulphite Fibre.—Sulphite fibre is made as follows: The wood, after being barked, is cut into small chips and is reduced in digesters with the aid of sulphuric acid. It has a longer fibre than mechanically prepared pulp. News and common wrapping paper are usually made of ground wood with 10 to 25 per cent. of sulphite to hold it. For a long time the sulphuric acid ate the linings, but this is now prevented by patented processes.

Soda Fibre.—Soda fibre is mostly made from poplar. It is softer and mellower, and is used for books and writing paper, but owing to the cheaper sulphite process, its use does not grow as fast as the latter.

Ground Wood Pulp.—The grinding of wood is done mostly by water-wheels, though steam is being more generally used, because of the constant and easily governed speed. The exhaust is economically used in the cylinders in which are dried the paper and waste. Water-power is used in the beating of the stock. There is a gradual adoption of electric power in paper mills, and its use is growing. The Millinocket plant of the Great Northern Paper Company in Maine, and some other plants, are so operated.

Products of Paper Mills.—Among the products of paper mills are ground wood pulp, soda and sulphite fibre, news, book, fine writing, wrapping, manila, straw-boards and tissue.

There are 663 Fourdrinier machines in use, of an average paper-making width of 86 inches. Some machines are as high as 144 inches capacity. There are in the paper mills of the United States 3,739 beating machines, 900 washing engines, 426 digesters, 1,168 grinders, with a capacity of 2,782,219 tons of paper and 1,536,431 tons of pulp. There are 2,106 steam engines, 3,209 water-wheels and 91 electric motors.

Later Processes.—An important feature developed in 1830, when Wooster and Holmes, of Meadville, Pa., took out patents for making paper from hemlock and whitewood. A second great stimulus was given in 1854, when a process of making white paper from straw was discovered. Three years later, J. A. Roth, of Philadelphia, patented a process of treating wood fibres with combination of sulphuric acid and chlorine bleaching agents, which process laid the foundation of a mighty industry.

Basis of the Pulp Industry.—But a still more significant and important invention was a boiler for making pulp from wood, which was brought out near Philadelphia in 1863, and which might be regarded as the basis of the mighty pulp industry of to-day, which has broadened the foundation of the paper-making industry more than any other single cause. The process for coating writing paper with a glossy surface was invented by Richard Magee, of Philadelphia, in 1864.

Bagasse Paper.—One of the latest innovations in paper making is in the use of bagasse, a by-product of the sugar plantation, especially in Louisiana. This product is compressed into a pulpy condition and then subjected to the customary processes of paper making. The "paper" is very tough, and can be compressed into a very solid and practically impenetrable substance. Arrangements have been made to manufacture barrels out of it, which will be cylindrical and of any desired size and length. Tests made show that sample barrels made will sustain a pressure of 1,000 pounds from the inside. The Du Pont Powder Company, of Wilmington, Del., now uses these barrels for shipping powder. The promoters of this enterprise see a vast variety of uses to which this product can be competitively put, it being possible to make barrels cheaper than out of lumber, and faster and more durable.

Production.—In Pennsylvania the valuation of paper and pulp products increased 56.5 per cent. between 1890 and 1900, but owing to the spread of the industry westward fell behind later. In 1900 New York led all States in the aggregate value of paper products, having taken the lead of Massachusetts. It led in news and wrapping and in wood pulp, and the increase amounted to 88.2 per cent. Wisconsin, because of its vast forests and abundant water-power, developed amazing paper and pulp capacity, the increase being 143.5 per cent. in the decade; Michigan showed an increase of 44.5 per cent. during that time. The industry is expanding more rapidly in Maine, New York and Wisconsin than elsewhere. The supply of pulp from Canada constitutes an important item. Large timber areas in more or less remote sections are being purchased and held for future supplies.

Comparative Summary of the Paper and Pulp Industry in the United States.

	1880	1890	1900
Number of establishments..	742	649	763
Capital invested	$48,139,652	$89,829,548	$167,507,713
Wage-earners..............	25,631	31,050	49,646
Wages paid................	$8,970,133	$13,204,828	$20,746,426
Value of products	57,366,680	78,937,184	127,326,162

Patent Medicine Industry.

Extent of Industry.—The patent medicine industry is represented, according to the latest government figures, by 2,026 establishments, an increase in twenty years from 563. The extent of the industry is shown by the fact that the value of products increased from $14,682,494 in 1880 to $32,620,182 in 1890, and $59,511,335 in 1900. This extraordinary consumption of proprietary medicines is due to a deeply-seated desire of a great many people to secure the benefit of medicine without the intervention of medical advice, especially in the innumerable instances of actual or imaginary slight indisposition. The industry has prospered and demand has been stimulated by a system of advertising which calls attention to almost every ill to which flesh is heir, and which offers a ready remedy, abundantly and specifically adapted to the correction of many ills.

Capital Invested.—The capital invested has increased from $10,620,880 in 1880 to $18,596,823 in 1890, and $37,209,793 in 1900. The wages paid to the 4,000 workmen engaged in 1880 amounted to $1,651,596, and to the 11,809 employed in 1900 the sum of $4,407,988 was paid. The value of the raw material used in the manufacture of medicines in 1900 was $18,185,513, and the value of the product, which was practically $60,000,000, shows the enormous profit realized through the sales.

Meritorious Properties. — The constantly increasing demand for these medicines would seem to demonstrate their efficiency for the purposes used, and appear to warrant the statement that many of the ills of the human body are practically similar and that the same remedies are applicable in a vast number of cases. The industry is growing rapidly, though by no means to the disadvantage of the medical fraternity which is increasing in point of numbers with great rapidity. Much patent medicine aims at tonicity of the system and seeks to act as a corrective to unhygienic habits and as a stimulant to abnormal bodily conditions which may not call for the more careful and professional attention of those who are learned in the science of medicine.

Paving Material Industry.

Kinds of Materials.—The growth of cities and towns, during the past fifty years especially, has developed an enormous demand for material for street paving. Earlier street pavements consisted largely of what are known as cobble stones, which are the debris of former geologic ages and which, under continuous tricuration of water and sand, assumed more or less spherical forms, and which are found in abundance in and along streams. They were largely used for many years, the interstices between the spherical shapes being filled with sand or other material and compressed into compact shape by means of rammers or other mechanical appliances. This pavement was at best a makeshift and the need for a smoother surface brought into existence a variety of material of which in these days asphalt is the chief. Asphaltum is found in vast beds in many parts of the world, much of which is used in the United States coming from warm climates, particularly the islands of the West Indies, in which Trinidad stands preëminent.

Deposits of asphaltum are found in various parts of the United States and it is being produced in supplies to meet some municipal requirements and which are growing rapidly. Wood has also been used, carved into convenient sized blocks and subjected to immersion in liquids which close the pores, rendering it suitable for vehicular traffic. This form of pavement, however, was found inefficient, not being sufficiently durable under the heavy wear and tear of vehicles. Asphaltum is now generally used by engineers and contractors and is recommended because of its demonstrated superiority.

Statistics.—The paving-material industry has grown with remarkable rapidity; in fact, there are few industries which can show such remarkable growth, especially during the past few years. This is evident from reference to government statistics which show that in 1880 only 46 establishments were reported. The number had increased in 1890 to 704 and by 1900 to 1,729. The number of workmen increased during those dates from 757 to 21,720, and from that figure to 34,090 in 1900. The wages paid increased from

$244,339 in 1880 to $9,425,298 in 1890 and $14,570,408 in 1900. The value of products increased during that time from $1,024,243 to $30,644,072 and to $46,447,719 in 1900. The industry is growing rapidly because of the enormous demands for paving material in all sections of the United States, in towns, cities and in rural sections. The demand for good roads is largely responsible for the prosperous condition of this industry, and the facility with which this pavement is laid, the comfort it affords, the manner in which it sheds rain, the ease with which it is kept clean and the smoothness which affords comfort in riding, all unite to make it the most popular, comfortable and valuable roadway which can be furnished.

Then and Now.—Thirty years ago there was not a yard of asphalt pavement in the United States; to-day there are about 38,000,000 square yards of sheet asphalt and 2,000,000 square yards of block asphalt, representing an investment by over 200 different municipalities of more than $100,000,000. The asphalt pavement, as laid in the United States, gets its name from the material which forms only 10 per cent. of the mass. An asphalt pavement is 90 per cent. sand and other mineral matter; the asphalt merely cements the grains of sand together. These pavements are also called bituminous pavements, as bitumen is the largest constituent of the asphalt, running in some asphalts as high as 95 per cent., and in other asphalts 55 per cent. Asphalt pavements are of two kinds, sheet asphalt and block asphalt. In the former the asphalt is laid in a continuous sheet; in the latter blocks, consisting of fine broken stone with asphalt as a cementing material, are made under heavy pressure, carried to the site of the work and laid in a manner similar to granite blocks and brick. Both forms in this country started about the same time. In 1870 Prof. E. J. DeSmedt, a Belgian chemist, laid what was probably the first sheet asphalt pavement in this country in front of the City Hall in Newark, N. J. Prior to this date, however, pavements had been laid with coal tar as the cementing material; but this pavement did not prove satisfactory, and no more of it is now being laid. In Prof. DeSmedt's mixture laid in Newark, Trinidad asphalt was used as the cementing material and this kind of asphalt has been used in about 85 per cent. of all sheet asphalt pavements laid since that date, and in all of the block pavements. Although Prof. DeSmedt laid other experimental mixtures besides the one in Newark, it was not until 1876 that it can properly be said that the sheet asphalt industry was started in this country.

Extent and Sources. — Up to the present date about 1,000,000 square yards of foreign rock asphalt pavements have been laid in the United States, and about 500,000 square yards of American rock asphalt, most of which are mined in Kentucky and Indian Territory. The asphalt industry, therefore, in the United States, is properly that of the artificial mixture as originally devised by Prof. DeSmedt. Starting with Washington, in 1876, the business soon spread to other cities; Buffalo in 1878; Baltimore in 1880; Boston in 1881; Erie, Youngstown and Omaha in 1882; Philadelphia, St. Louis and Louisville in 1883; Chicago and New Orleans in 1884; until at the present time sheet asphalt pavements are laid in upwards of 150 cities in the United States and Canada. This form of pavement is also now being laid in London, Paris, and Liverpool in competition with rock asphalt; also in Buenos Ayres, the City of Mexico, Santiago de Cuba, and other foreign cities.

As an illustration of the rapid development of the industry, it may be noted that the number of square yards of sheet asphalt pavements laid up to 1880 was 300,000 square yards; in 1885, 1,800,000; in 1890, 8,100,000; in 1895, 21,500,000; and in 1900, 38,000,000 square yards. After twenty-four years of practical use the value of asphalt as a paving material has been demonstrated, and the laying of these pavements is now a substantial business, employing thousands of men and using millions of capital. It must not be assumed that no difficulties arose in the development of the business. Prejudice had to be removed and the opposition of those interested in other forms of pavement had to be overcome. To-day contractors are willing to lay an asphalt pavement on Lower Broadway, New York, and guarantee it for ten or fifteen years, whereas ten years ago no contractor would have thought of taking such a risk. Asphalt pavements have now become the standard for large cities, and some smaller cities and villages are using it in competition with cheaper materials.

Famous Deposits.—The deposit which has furnished over 85 per cent. of the asphalt used in the United States is the famous Pitch Lake of Trinidad, B. W. I., just off the coast of Venezuela, and which Charles Kingsley, an eminent and conservative writer, described as one of the wonders of the world. This deposit occupies a bowl-like depression, probably the center of an extinct mud volcano, some of which are found in other parts of the Island. It covers about 114 acres, is nearly circular in outline and a little less than half a mile in diameter. The center of the deposit is about three-quarters of a mile from the shores of the Gulf of Paria, and about 135 feet above the level of the sea, making it easy of access and simplifying the question of shipment. The surface is hard enough, except in irregular patches in the center, to bear the weight of carts and mules. It is necessary, however, for one to keep moving, otherwise he soon sinks in the material, which, under the hot rays of the sun, becomes quite mobile, although not sticky, owing to the large amount of water which it contains. When asphalt is dug from any portion of the deposit, in the course of a few days the hole is filled by new material coming from below; but the entire area of the lake, 114 acres, is lowered in consequence, showing that the mass acts as a liquid, of less mobility, however, than water. The composition of the asphalt is of remarkable uniformity, no matter from which portion of the lake it is taken. Samples taken 135 feet deep at the center did not differ in composition from those taken on the surface a few feet from the shore, showing the homogeneousness of the entire mass. Then, too, the surface is in constant motion. There are on the surface of the lake half a dozen or more islands, from 50 to 150 feet in diameter, composed of floating vegetation, with trees 30 or 40 feet high and dense undergrowth. From accurate surveys it was found that one of these islands in one year moved over 25 feet. The resemblance of this deposit to a lake may therefore be summed up as follows: Its occurrence in a basin with well-defined shores and bottom; its movement as a mass, preserving its level; the uniformity of its composition; the movements of its surface; the presence of islands and the existence of springs.

The Lake.—From levels taken in February, 1893, and again a year later, it appears that the center of the lake is almost a foot higher than the edges. This is probably due to the ebullition of the soft asphalt near the center. Levels have been taken every year since that date and it appears that the lake preserves its contour, although the general level has been lowered nearly 4 feet in the past eight years. It has been found that the removal of about 18,000 tons of asphalt will lower the level one inch, and as the output is about 100,000 tons per year the level is lowered from 5 to 6 inches per year. From the borings, however, it is evident that for several generations to come there will be no shortage. These borings were made with the ordinary portable water-jet machine, such as is used in making borings through sandy material, and it was well suited for the purpose. It took several days to make the boring in the center of the lake, and by that time the casing had gotten so far out of plumb, due to the motion of the asphalt, that it was impossible to drive it any deeper. This casing finally disappeared, although its top originally stood six or eight feet above the surface.

The Digging of Asphalt.—The asphalt is dug by means of picks or mattocks just before dawn, when the asphalt is comparatively brittle, and in the early days of the industry was loaded upon carts and taken to the beach, where it was stored until the arrival of vessels, or dumped directly into lighters, which carried it to the sailing vessels or steamers anchored half a mile out from shore. As the business increased it became necessary to install more rapid and economical methods of loading.

Composition.—The crude Trinidad Lake asphalt is an emulsion of water, bitumen, mineral matter and some organic matter not soluble in carbon disulphide (which is the solvent for bitument), the relative quantities being as follows:

Bitumen	40 per cent.
Water	28 " "
Mineral Matter	25 " "
Organic, not soluble	7 " "
	100 per cent.

From this analysis it appears that less than one-half of the crude asphalt as it comes from the lake is bitumen, and that a large percentage is mineral matter.

Of the 30,000,000 yards of Trinidad Lake asphalt pavement now in use in America, the Barber Asphalt Paving Company has laid about 14,000,000 yards.

Perfumery and Cosmetics.

Material for Perfumes.—The perfumes for the toilet are usually termed simple or compound; the former are called extracts or essences, the latter are termed bouquets. By far the larger number of materials used by the perfumer comes from the vegetable kingdom, but there are certain exceptions, such as musk and ambergris. The number of flowers used by the perfumer is very limited, but by judicious combination or blending almost any odor may be obtained.

Sources of Perfumes.—The odors of plants reside in different parts, in the roots, sometimes in the stem, in the wood, in the leaves or in the seeds. Some plants yield more than one odor—the orange tree, for instance, gives three. From the rind comes the essential oil of orange. The fragrance or odor of plants is due to a perfectly volatile oil contained in small sacks. Some exude by incision. Many odors that are agreeable are not applied in perfumery for handkerchief use, but are used in the manufacture of soaps and sometimes as medicines. The odors of flowers are more generally secreted during the sunshine or during the daytime. Some yield no odor in the day, but are very fragrant in the evening.

Extracting Processes.—Perfumes are extracted from flowers by absorption, from roots by trituration, from seeds by distillation. There are four processes followed in obtaining perfumes, namely—expression, distillation, maceration and absorption.

Pomades.—Of all processes for extracting perfume of flowers, that of absorption is the most important and least understood. It yields only the most exquisite essences indirectly. By this process is obtained nearly all fine pomades known as French pomata.

France is the land of pomades, and her manufacturers enjoy celebrity because of honesty in the preparation of their products. Essential oils and alcoholic essences are added at the lowest possible temperature with fat of young healthy animals; lard and beef and mutton suet, beef marrow, veal fat, and bear fat are used in the manufacture. These materials are employed in varying proportions with various essences to produce desired products.

Among cosmetics may be mentioned almond balls, almond meal, almond paste, amandine, eyebrow pencils, lotions without number, milk of roses, oil of almonds, French milk of roses, milk of dandelion, milk of elder, olivine, pastes and cosmoline.

The processes of manufacture are complex and require an intimate knowledge of many chemicals and their proper uses. Emulsions are sometimes made of sweet almonds, blanched and beaten to a smooth paste, adding distilled water during trituration. Another formula is: Blanched almonds, 5 drams; gum Arabic in powder, 1 dram; water, 8 fluid ounces; gradually triturated. The first method gives the common milk of almonds; the second is a powerful cosmetic.

Almond paste is made of bitter almonds blanched and ground, honey, yelk of eggs, almond oil, otto of bergamot and otto of cloves. The eggs and honey are worked together first, and oil is then gradually added, next the ground almonds, and last the perfume.

Eyebrow pencil is made of ½ pound suet, ¼ pound curd soap and ivory black. A pomade for freckles is made of citrine ointment, oil of almonds, spermaceti ointment, otto of roses, all well mixed with a wooden or bone knife. Another good pomade is made of 20 grains levigated sulphate of zinc, 1 ounce elder-flower ointment, well mixed in a mortar.

Lotions.—A good acetic lotion, useful for bruises and sprains, is made of 1 part strong vinegar and two or three parts water. Another used in case of burns, sprains or skin eruptions is made of ¼ ounce sugar of lead, distilled in 1 pint of soft water to which a little vinegar may be added. A lotion for the strengthening of inactive hair follicles or baldness is 1½ drams crushed alum distilled in a pint of soft water, to which a little rose water may be added.

A skin lotion may be made of 1½ ounces of glycerine with a pint of water. It removes dryness and is good for chapped hands.

Sunburn is removed by a paste made of milk, 20 ounces; carbonate of soda, 1 ounce; glycerine, 1 ounce, and powdered borax, ½ ounce. Cosmoline and vaseline are variable mixtures of paraffine and volatile oils. They are the result left from the distillation of petroleum purified by filtration over animal charcoal.

Use of Cosmetics.—Cosmetics are employed to impart beauty to the complexion. Rouge and face powders come under this head and are made in great variety, for all types, from the brunette to the delicate blonde. The composition of these powders is in varying proportions, based mainly on powdered chalk, starch, talc or similar ingredients. For white powder, oxide of zinc is used. Some face powders are made of starch, oxide of bismuth. Enameled powders are sometimes made of French chalk (pearl white) and rouge.

Phonographs and Graphophones.

The Birth of the Phonograph.—In the latter part of 1877 Thomas A. Edison showed to a few privileged friends a modest little machine which, on being turned with a crank, said: "Good-morning!" "How do you do?" "How do you like the phonograph?" The invention was a striking and interesting novelty, and soon attracted the attention of the entire world. Its rapid introduction followed, and it is now one of the essential requirements of every well-conducted business office. The phonograph is really a development of the phon-autograph, which was invented by Leon Scott in 1857.

Improvements.—The phonograph was improved by Bell and Tainter, which improvement consisted in the substitution for the tin-foil sheet used in the older machine of a surface of wax which was fashioned into a cylinder. Into this the stylus cut, dislodging a minute filament or shaving, and formed a record which could be distinctly heard.

The Graphophone.—Perhaps the greatest use of the graphophone now is for amusement purposes, its songs and orchestral and solo renditions constituting to-day a great library of wax cylinders, readily catalogued and sold by thousands. A very important feature in record making, from the commercial point of view is in the duplicating of records. Both the recording stylus and reproducing ball are made of sapphire, chosen on account of its hardness to resist the great frictional wear to which they are subjected. When a record is to be effaced from a cylinder it is turned off smooth on a lathe, and the cutting tool or knife for this purpose is also made of sapphire.

Berliner's Improvement.—About 250 patents have been granted on phonographs and graphophones. One form of phonograph is actuated either by electricity or spring-power. The gramophone, the invention of E. Berliner, instead of having a wax cylinder, employs a flat disk on which the record is formed as a volute spiral groove gradually drawing toward the center.

The Product of Many Inventions.—The phonograph as it is to-day represents the result of some 400 inventions, of which 353 were issued up to 1900. The production of phonographs practically began after the introduction of a patent to Thomas A. Edison in 1878. The greatest advance in the art was made in 1886, by cutting the record in a solid body instead of indenting it in the vibratory style.

In 1900 there were 11 establishments making phonographs and graphophones, having an invested capital of $3,348,282, employing 1,267 wage earners, to whom was paid $608,490, producing goods worth $2,246,274.

Earnest efforts are still being made to secure still more satisfactory results and with the promise of ultimate success by enthusiastic inventors who see a great field for a more perfect instrument.

Photography.

Origin of the Industry.—Photography may be briefly defined as the art of producing pictures by the action of certain sensitive substances under the influence of light. It might be said that it sprang from the discovery made some three hundred years ago that the luna cornea of the alchemists, *i. e.*, silver-fused chloride would darken on exposure to light. In 1777 Schele, the Swedish chemist, noticed that the power which produced this darkness resided chiefly in the violet end of the solar spectrum. Thomas Wedgewood, in 1802, published his method of taking profiles upon paper, or white leather treated with nitrate of silver and exposed to the light of the sun under the object to be represented. Sir John Herschel further improved the process.

The Calotype Process.—In 1839 Henry Fox Talbot made known his calotype process in which paper, having on its surface chloride of silver, was exposed in a camera obscura and the image developed by a solution of gallic acid. This was an epoch in the history of photography. The method was further improved by the substitution of silver iodie fornchloride. Other improvements soon followed, including the world-famous Daguerreotype process. The Archer process, developed in 1850, followed, and the next great step was the adoption of alkiline development for dry plates.

The Collodion Process.—The collodion process still holds its own for some purposes, but the art was once more revolutionized by the introduction of gelatine, which may be spread either upon glass or paper, as a medium for holding the sensitive salts. The sensitiveness of these gelatine plates is so great that photographs of express trains in motion, leaping horses and birds on the wing are of every day occurrence.

Photography in Astronomy. — The application of photography to astronomy has greatly increased our knowledge in that field of science. Many master minds are now engaged on the further development of some of the lesser investigated fields of this interesting art.

The Lens in Photography.—In photography the thickness of the lens has much to do with results. The sphericity of surfaces is an important consideration. Lenses which appear spherical are often a series of elevations and depressions. An elevation gives a shorter focus for those rays which fall upon it; depth of focus and speed are incompatible for well-known reasons. Flatness of field and distortion in lenses are variable qualities. It is necessary that a disk should be of the same consistency throughout. The arranging of lenses in portrait combination involves an exact knowledge of the laws of photography. When glasses have been used they are difficult to clean and if they have been varnished they must be soaked in a solution of common soda or carbonate of potash until the varnish peels off.

Use of Alkiline Salts.—Alkaline salts are the most important among the many chemicals used in photography. Sodium carbonate, the most useful alkiline salt, is made by three processes—one the ammonia process, being perfectly free from dangerous impurities.

Rules for Length of Camera. — The use of "photo powders" has more than doubled the field of activity of instantaneous photography. The rule for calculating length of camera required is: Multiply the focal length of the lens used by the number of times of enlargement required and add the focal length to the product. The focus of a quarter-plate lens is, say, 6 inches. Say the negative is to be enlarged three times. Multiply 6 × 3 = 18 + 6, focal length, = 24 inches, the distance between the ground glass and the lens. The negative to be enlarged must be absolutely perfect as regards definition, slightly dense and full of detail possessing as little granularity as possible. Photography is not only a science but an art, and calls for innate knowledge and also supreme tact, which many people regard as luck, and a constant and thorough study.

Of recent years photographers seek to secure a thoughtful instead of blank expression on the face of the subject.

Comparative Summary of the Photographic Industry.

	1880	1890	1900
Number of establishments...	1,287	3,105	7,553
Capital invested.............	$3,131,895	$7,804,532	$13,193,589
Wage-earners................	3,977	6,967	8,911
Wages paid..................	$1,751,118	$3,472,643	$4,013,018
Value of products...........	$5,935,311	$15,488,324	$23,238,719

Comparative Summary of the Photographic Apparatus Manufacturing Industry.

	1880	1890	1900
Number of establishments ..	10	25	48
Capital invested.............	$90,800	$362,834	$1,849,724
Wage-earners................	104	506	1,961
Wages paid.	$41,314	$262,755	$779,890
Value of products...........	$104,305	$624,342	$2,026,063

Piano Making and Makers.

The Origin of the Piano.—The piano was developed from the clavichord and harpsichord, and differs chiefly from them in the introduction of hammers. Priority of invention may be due to an Italian, Schroter, who made an instrument in 1714, but the piano made five years before, referred to below, leaves this point in question. It has been successively improved by a host of inventors, and its range from four to five octaves has been increased to eight. In the earlier pianos, the hammers were raised from below by a button attached to an upright wire fixed on the back end of the key. This was improved by a pointed upright piece called the nopper. The early part of the eighteenth century affords many evidences of the gradual approach to the present piano.

Historical.—The Greeks had a long box of thin wood with a wire stretched across it which was used down to the Middle Ages, when several wires were added and made to vibrate by means of a keyboard similar to that already used in organs. These wires were struck with hammers which were raised and pressed against the wires by the player.

The Harpsichord.—The harpsichord was a modified harp which was enclosed in a box and the wires were plucked by quills attached to the end of each key. This crude instrument was much used by Beethoven, Mozart, Handel and other great composers.

The First Piano Maker.—Christofori, of Florence, Italy, in 1709, produced the first piano with a soft and loud, in which the wires were struck with a hammer and which constitute its essential principle to-day. By 1760, factories had been established in Germany and England. Pianos began to be imported, one of the first being in 1784, but the difference of climate and the ocean voyage caused the strings to rust and the destruction of tone. This led to the establishment of piano making in the United States. One was made by John Behrent, in Philadelphia, in 1775. Ten years later their manufacture began in New York; in Boston in 1800, and in Baltimore in 1802.

The Infancy of Piano Making.—The special feature of the present piano was developed between 1825-1840, conspicuously by Jonas Chickering, which consisted in the use of an iron frame in a single solid piece, which admitted a much greater tension of the strings with a corresponding improvement in quality and tone. The frames of the earlier pianos were of wood which swelled and contracted with atmospheric changes. The strings stretched upon it were never subject to the same strain and were constantly out of tune, even though they were not strained to the tension of violin strings. In 1876, frames were made capable of sustaining a string tension of 12½ tons. Theodore Steinway followed this by making frames capable of sustaining a suspension of 30 tons. These improvements were adopted all over Europe.

Square, Grand and Upright Pianos.—Nearly all pianos were square for the first half of the last century. The first American Grand was made by Jonas Chickering in 1840. Up to 1866, 97 per cent. were square. A revolution set in in favor of the upright, and in 1900, 97.4 per cent. of all were made upright, 2.5 per cent. grand, and 1-10 of 1 per cent. square.

Piano Players. — Perforated sheets of music, caused to move by pedal action or electricity, afford enjoyment to non-players. The most used device is the pneumatic piano player, operated by the feet. Over 55 patents have been granted for these devices. Among those well known are the "Angelus," "Æolian," "Peerless," and the "Pianola." Over 30 companies are now engaged in the manufacture of various forms of players. The popularity of the pneumatic piano player, which is operated by the feet, is due to devices by which the performer is able to control tempo, volume of sound and accentuation of particular notes or parts.

First Portable Grand.—Isaac Hawkins, of Philadelphia, invented and produced the first cottage pianoforte, or "portable grand," as he called it, in the year 1800, and his invention anticipated nearly every discovery that has since been introduced in America or Europe as novel. He used an iron frame independent of the case and suspended his soundboard in this frame, strengthened by rods, combined with an iron "upper bridge." He invented an apparatus for tuning by mechanical screws to regulate the tension of the strings and then took his bundle of inventions to London. Robert Wornum, in 1811, improved on it, and in 1826 patented a cabinet piano.

An Important Event.—A turning event in the industry occurred in 1821, when Samuel Herve fixed an iron string plate to a square piano which acted as a more even counterpoise to the drawing or tension of the strings and prevented their undue length behind the bridge. The introduction of the log, iron and steel resistance bars cannot be assigned to any one inventor, though a complete system of nine resistance bars from treble to bass was introduced in 1823. James Broadwood, in 1827, claimed the combination of string plate and resistance bars.

The Harmonic Bar.—Pierre Erard introduced the "harmonic bar" in 1838, and the Collards introduced a method of fastening the strings on the string plate, depending on friction and which dispensed with the eyes. Alpheus Babcock introduced iron into the piano in America and cast the metal plate and bars in a single piece. The single casting resistance framing was taken up by Conrad Meyer in Philadelphia, in 1833, which was improved upon by Jonas Chickering, of Boston, who applied it to the grand and square pianos. The first suggestion of overstringing was made by Theobald Boehm in 1831.

Mechanical Features.—Henry Engelhard Steinway, in 1855, effected the combination of an overstrung frame with an American iron frame, which attracted world-wide attention and resulted in revolutionary changes. The Chickerings claim to have anticipated this application. It gave a powerful impetus to piano making. In spite of the advantages there are grave disadvantages which future inventors will endeavor to remedy. They refer to the disturbing of the balance of tone by introducing thick, heavy basses, which, like the modern pedal organ, bear no just relation to that part of the keyboard where the part-writing lies. The great increase of the tension which is held up as a gain, acts prejudicially upon the durability of the instruments as no artificial screwing up of the soundboard can always preserve the elasticity of the fibres of the fir-tree of which it is made. The remarkable improvements have rendered very high tensions practicable.

Two Schools of Makers.—There are two schools of piano makers in America, known as the "New York School" and the "Boston School." The full cast-iron frame originated in Boston, but Boston manufacturers clung to what other makers declare is an inferior action. The Boston make is light in action, and thin, sensitive and very musical in tone. The New New York make is essentially German in its action, tone and touch.

Statistics.—There are important problems yet to be solved in piano making. The industry is profitably conducted in several States, New York taking the lead where it was started in 1785 by George Ulshoefer, a German musician. In 1900 there were 193 establishments in that State en-

MANUFACTURE OF MUSICAL INSTRUMENTS IN THE UNITED STATES. FROM TWELFTH CENSUS

	Musical Instruments all Classes	Pianos	Organs	Musical Instruments not specified
No. of Establishments	621	263	129	229
Capital	$47,751,582	$38,843,494	$5,011,987	$3,896,101
Land	$3,233,659	$2,865,118	$196,371	$172,170
Buildings	$5,923,074	$4,885,171	$667,641	$370,262
Machinery, Tools, & Implements	$4,334,315	$3,002,426	$602,313	$729,576
Cash & Sundries	$34,260,534	$28,090,779	$3,545,662	$2,624,093.
Salaried officials, clerks, etc.	1,682	1,250	274	158
Salaries	$2,164,171	$1,722,991	$299,435	$141,745
Wage Earners, average No.	23,765	17,925	3,435	2,405
Total Wages	$12,801,767	$9,849,001	$1,720,727	$1,232,039
Miscellaneous Expenses	$3,786,929	$2,912,051	$603,785	$271,093
Cost of Materials.	$18,607,537	$15,182,035	$2,220,165	$1,205,337
Value of Products.	$44,514,463	$35,428,225	$5,691,504	$3,394,743

JEWELRY, TIMEPIECE & INSTRUMENT INDUSTRY.

	NO. OF ESTABLISHM'TS	WAGE EARNERS	WAGES PAID DOLLARS	VALUE OF PRODUCT. DOLLARS
JEWELRY	908	20,676	10,746,375	46,501,181
JEWELRY CASES	63	819	322,566	1,156,977
WATCHES	13	6880	3,586,723	6,822,611
WATCH CASES	30	3,907	1,924,847	7,783,960
JEWELRY REPAIRING	12,229	8,380	4,683,086	20,235,039
WATCH & CLOCK MATERIALS	20	231	152,234	345,347
CLOCKS	46	6037	2,650,703	7,157,856
SILVERSMITHING	44	1,937	803,662	2,936,462
SILVERWARE	59	4376	2,639,480	10,569,121
PLATED WARE	66	6392	3,088,224	12,608,770
GOLD & SILVER LEAF	93	1,163	498,692	2,666,224
GOLD & SILVER REFINING (NOT FROM ORE.)	57	219	141,400	11,811,537
INSTRUMENTS, SCIENTIFIC	265	2,786	1,433,715	4,896,631
INSTRUMENTS, SURGICAL.	219	1,539	620,801	3,932,358

MONETARY AND COMMERCIAL SIGNS.

$	Dollar, as $375.
¢	cent, as 12¢.
s-	shilling, as $^{s}/6^{d}$ = 1s. 6d.
£	Pound, as £35.
℔	Pound (Weight) as 24lbs.
@	At, as Wheat @ $1.00 per bushel.
℘	Per, as Sheep @ $4.00 ℘ head.
%	per cent, as money at 6%.
a/c	Account, as Smith in a/c with Jones.
B/L	Bill of Lading.
c/o	Care of.

L/C	Letter of Credit
A1	First class Vessel Register.
A (in Red)	Second class Vessel Register
Æ	Third class Vessel Register.
E	Vessel Register for Carrying Freight any distance not liable to sea damage.
I	Vessel Register for Carrying above Goods short distance.
M.C.	Denotes Vessel inspection and all O.K.
XX	Ale of Double Strength.
XXX	Ale of Triple Strength.

gaged in piano manufacture, which produced work valued at $15,509,839; owing to the extension of the industry in other States a slight decrease in production is noted in that State. The piano has become almost a necessary part of household equipment, even when taste and skill do not demand it. The industry has grown steadily during the past twenty years and promises to engage the attention of piano makers on a much more extended scale in the future.

Comparative Statement of the Piano Industry in the United States.

	1880	1890	1900
Number of establishments ..	174	236	261
Capital invested...........	$9,869,577	$18,430,872	$38,790,494
Wage-earners	6,575	12,432	17.869
Wages paid.................	$4,663,193	$8,369,347	$9,818,996
Value of products	$12,264,521	$25,766,368	$35,324,090

Pipe Coverings.

Steam Economy.—One of the vital points which users of steam have to keep constantly in mind is the proper covering of pipes carrying steam. For this purpose many varieties of covering are made, and it comes in many forms. Asbestos is the main material in many kinds of covering.

Kinds of Covering.—It is known as asbestos-magnesia, asbestos-magnesia block covering, magnesia sectional lagging, asbestos-cement felting, hot-blast cement, furnace cement, stove-lining cement, retort cement, rope-packing cement, asbestos fibre, asbestos-wick packing, asbestos cloth, asbestos sheet millboard and roll millboard, and asbestos sheeting. Woven sheeting, metallic woven tape, metallic woven gaskets and metallic piston packing are also made of asbestos, as well as India rubber woven sheeting and woven tape.

Asbestos Fibre.—Packing on pipe coverings is absolutely fireproof and a non-conductor of heat. It confines the heat to the pipes and prevents steam condensation, thus saving fuel. Asphaltum varnish is frequently used to coat pipes exposed to the weather or dampness, which renders them impervious to moisture and adds to their efficiency. Much pipe covering is composed of asbestos fibre, magnesia and other fireproof non-conducting materials, which are molded into sections and form a light, porous composition containing an infinite number of minute dead-air cells, which are the basis of heat insulation. Some kinds of covering are made, specially adapted to low-pressure steam pipes, in three standard thicknesses of one-half inch, three-quarters inch and one inch. There is also supplied an argentum covering, which consists of chemically treated woolen felt built up in layers, and which is treated in a manner to render the woolen felt impervious to moisture.

Asbestos Felt.—Asbestos cement felting is composed of asbestos fibre and adhesive fireproof cementing compounds put up in a dry state. This cement readily adheres to iron and other surfaces. There are various kinds of covering manufactured especially to serve certain specific requirements, from which the steam-user can readily select the exact sort of protecting material which his machinery requires.

Asbestos Cloth.—The manufacture of asbestos cloth has recently been stimulated by the alarmingly frequent recurrence of destructive fires. This material, when honestly made, is absolutely fireproof, and is not affected by acids or oils. It is to some extent used for theater curtains, screens, aprons, gloves, mittens, grate blowers and table covers, and is also extensively used for filtering purposes. Asbestos millboard is used for protecting walls, ceilings and joists from overheated surfaces.

Other Products.—Asbestos air-cell fire-board is made of corrugated asbestos felt in two or more layers. The corrugations are reversed in each layer. It is used for fireproofing buildings, ceilings and walls. Asbestos sheeting is composed of pure asbestos fibre, and is used for lining weather-boards, floors, and for covering hot-air pipes and for making fire screens. The production of material of which asbestos is the base has met with a very wide acceptance and has done much in the way of decreasing danger from fire.

Plasterers and Plastering.

Plasterers Long Ago.—The old books contain frequent allusions to the plasterer and his art. The ancient temples and edifices manifest his wonderful skill. The plasterer was an artist as well as a craftsman in earlier times and the evidences of his workmanship command admiration, even to this day. Shakespeare, in "Henry VI," makes one of his personages say: "My father was a plasterer." To be a plasterer then was no small honor. Even in the time of Plutarch, plastering was a highly honored craft, but then as later the plasterer's work was seen only in the more costly and pretentious buildings. Plutarch, speaking of one of his heroes, says: "Of all his houses he had abroad in the country, he had not one plastered or rough-cast." The Greeks made much of plaster, especially along lines of ornamentation, and called it emplastron, from which our word plaster is derived. The Romans used it, but in a less degree and less artistic manner. Frequent mention is made of plaster down through the Middle Ages, but the quality of work suffered a gradual deterioration until the revival of handicrafts.

Composition of Plaster.—Plaster may be defined as a composition of sand, lime and water, with or without hair as a bond, though this definition is by no means complete or exact. Modern methods of manufacture show a wide departure from primitive methods, in which economics are subserved which makes its use available in houses of cheapest design. Formerly walls were plastered above the wainscoting and then colored. Ceilings were frequently plastered and then ornamented, many of which are the admiration of lovers of art to this day.

Tools of Trade.—The usual tools of the plasterers are the lathing hammer, a hand float, a quick float, a "darby," which is a long, two-handled float for forming the floated coat of lime and hair, brushes for fine work, jointing trowels, jointing rules, molds for cornices, and a straight-edge to bring the plastering on the walls or ceiling to a perfectly even surface by traversing it or separating the coarser materials which enter into the composition of the plastering mortar. These are thrown against its outer face to separate the particles which are too large for the purpose, from the finer. Besides these tools, the plasterer sometimes uses the spade and hod, a rake and a server.

Materials.—The plasterer works in plastic adhesive compositions which are laid on walls, internally or externally, to produce an even, delicate surface capable of receiving decoration in color or otherwise. The grades of plastering work are many, from common lime to the making of imitations of marbles. The materials are lath, lath nails, lime, sand, hair and plaster, and a variety of stuccos and cements, together with various ingredients to form coloring washes. Ordinarily, the plasterer is enabled to wash and whiten the ceilings and walls of rooms from trestles, but in many cases scaffolding is indispensable. The coarse stuff used is composed of ox or horse hair from the hide, with lime and sand mortar, which acts as a sort of mesh or net and forms a coarse but plastic felt. Fine stuff is made of fine white lime, well slaked with water; gauge stuff is composed of about three-fourths putty and one-fourth calcined gypsum or plaster of Paris.

Stucco.—Bastard stucco is made of two-thirds fine stuff without hair and one-third of very fine and clean sand. Common stucco is composed of about three-fourths of clean sharp sand and one-fourth of best lime well mixed. This must be thoroughly protected from the air until used. Portland cements is much used for outside stucco, as it is proof against water, when used as a mortar in setting brickwork and in the composition of concrete for foundations. Among the well-known cements which take a brilliant polish which resemble marble are Keene's marble cement and Parian's cement. They become very hard in a short time and can be painted in a few days. Tints can be made up from these cements for colored decorative work. Two cements freely used but now discarded were known as Hamelin mastic and mastic de Dhil.

Coats.—The various coatings of plastering are distinguished in this way: on laths, plastering in one coat simply is said to be laid; in two coats, laid and set; in three-coat plastering on laths, the first is called the pricking up; the second is said to be "floated;" and the third, "set." On brick or stone walls, plastering in one plain coat is termed "rendering;" with two coats the wall is said to be rendered and set, and in three—rendered, floated and set.

Methods.—Before beginning to lath a ceiling, the plasterer applies a long straight-edge and makes up for any slight inequalities in it. This operation is called firing. If a ceiling is to be divided into departments of panels the projecting or depending portions are bracketed or cradled down to receive the laths. When the lathing is completed the work is either laid or pricked up, according to the number of coats it is to receive. This work is done by the trowel only. If the work is to be of two coats, it is roughly swept, then dried with a birch broom to roughen its surface, and then a coat of fine stuff is put on. For floated or three-coat work, the first or pricking up is roughly laid on the lath; when the pricked-up coat is sufficiently dry, preparations are made for floating. Ledges termed screeds or margins of lime and hair 6 or 8 inches wide, extend across the whole breadth of a ceiling, or height of wall or partition. The screeds are gauges for the rest of the work.

When the mortar in them is set, the interspaces are filled up flush. To perfect the work the screeds on ceilings should be leveled and on walls and partitions, plumbed.

Moldings and cornices are formed with running molds and are generally executed before the second coat is put on the walls and ceilings.

Plaster, How Used.—Plaster is laid on by hand in several thicknesses of about $\frac{1}{8}$ to $\frac{1}{4}$-inch each, either on bare masonry walls or on a special screen of lathing made for it, to either of which it adheres by entering into and keeping itself in the joints and openings by its adhesive quality. It is important to prevent blistering that the lime be thoroughly slacked, and most plasterers allow their plaster to stand a time before using. Wrought-iron nails are preferable for oak lath. Lath is made in 3 or 4-foot lengths, and, according to thickness, is called single or double, the latter being double thickness. Both lengths are used in order to break joints to improve the "keeping" or holding of the plaster. Thin lath are safe for partitions, where the strain of the plaster is not so great. The ends of the lath should not be lapped on each other when they terminate on a quarter or bottom, which is sometimes done to save a row of nails, and such practice leaves only $\frac{1}{4}$-inch for the thickness of the plaster.

Laying.—Laying or rendering is the first process when the plaster has two coats or set work. What is called pricking-up is the first coat of three-coat work. Coarse stuff is first used, which is made with chalk lime, slacked with water, afterward evaporated and mixed with an equal quantity of clean, sharp sand and ox hair at the rate of 1 pound of hair to 3 cubic feet of stuff. After this is laid on it is scored diagonally to give it a key or tie for the next coat.

Fine Stuff.—Fine stuff is a mortar made of fine white lime, exceedingly well slacked with water, which forms into a paste, to which a small quantity of hair is added. It is most completely macerated and is called plasterers' putty.

Setting.—Setting is a second coat upon laying, or a third coat upon "floating." The setting is spread with a smooth trowel and as the plasterer does this he draws the brush, full of water, backwards and forwards over its surface, producing a fair face for the work.

Floating.—Three-coat work is called floated, taking its name from a float which is moved in every direction with the plaster while it is soft. There are three sorts of floats, the hand float, the quick float, used over in angles, and the Derby, which is used by two men.

Plaster and Float.—Plaster, float and set, is the term used for three coats of plaster on laths. The floating is fine stuff, with hair. When the floating is sufficiently set it is swept with a birch broom for the third coat or setting, which should be of plasterers' putty.

Stucco Work.—Bastard stucco is of three coats—first, roughing; second, floating; and finishing coat. Troweling stucco is the best sort of plastering and is formed on a floated coat of work which must be perfectly dry. Ceilings are set in two ways, where the setting coat is composed of plaster and putty and where the plaster is without hair. "Plugging" is plaster laid on boards fitted in between the joists of the floor to prevent the passage of sand in which coarse stuff is used. In using "roughcast," the wall is first pricked up with a coat of lime and hair on which a second coat of same material is laid, over which roughcast is splattered, and all is dried together. Roughcast is a composition of small gravel finely washed, mixed with pure lime and water in a semi-fluid state.

Rules for Stucco Work.—In plastering with stucco the dust is brushed off and the wall is then wet; the stucco is applied in a fluid state with a broad and strong brush like common whitewashing. Screeds must be formed at the highest and lowest extremities of the wall, or of that part of the wall which is in the same vertical line and is not intercepted by strong courses. When the stucco is perfectly dry it may be painted in oil or colors and in either case it is generally ruled over the surface with a lead point to give it the appearance of gauged stone work.

Scagliola.—Scagliola is a species of plaster or stucco used in Italy over three centuries ago. Marezzo marble is made of cement mixed with fibre for strength and to resist a blow. Slabs are bedded on plaster of Paris and with cramps and dowels like marble. Every variety of marble can be imitated in it.

Returning to Older Styles.—The intensely utilitarian conceptions and demands of the present day have robbed the craft of those artistic features which distinguished it in the infancy of its existence. Plastering is now a part of construction rather than, as formerly, an addition to it. Of late years evidences have been manifested of a return in greater or less degree to the art of plastering as it was developed by its earlier masters, when debasing influences of competition and cheapness played no or very little part, and when art and beauty were uppermost in the mind.

Plated and Brittania Wares.

Composition of Britannia.—Britannia is a white metal alloy of tin, antimony, bismuth, copper, etc., somewhat resembling silver and largely used for tableware. Britannia metal is used for spoons, handles, pillars, spouts, castings hardening and various other purposes. Britannia for spoons is made, usually, in the proportions of 100 parts tin, 10 parts antimony and 5 parts hardening, with one or two other mixtures. For handles the proportions are 2 of copper, 5 of antimony and 140 of tin. Britannia for castings is made in the proportion of 5 parts antimony, 5 parts hardening and 100 parts tin. It will therefore be seen that the main ingredients are tin, copper and antimony. Hardening for britannia is mixed separately from other ingredients, and is made of copper and tin in the proportion of 2 to 1. The compositions are various for the different purposes.

Home of the Industry.—The industry of britannia making has developed to large proportions, and its chief home is in Connecticut, where large plants, finely equipped, are engaged in the manufacture of this product, and which are equipped with machinery of special design and construction, adapted for the most economic production of this valuable metal.

Plated Ware.—Plated ware is made with a thin covering or coating of silver or other metal, either by a mechanical process or hammering or a chemical process, as in electro-plating. The plating industry has, since the cheapening of silver, developed into a very important industry. The discovery of large bodies of silver ore, accompanied with the demonetization of silver as a currency, has resulted in its great cheapening, and in this way has brought about the building up of a profitable industry. The invention of mechanical appliances and the better understanding of the chemical and electrolitic action of metals, has further aided in the strengthening of this industry. The popular love for silver and its brightness in articles of domestic use has created a very heavy demand for plated ware, which is increasing year by year.

Other Compositions.—Among the various preparations may be mentioned the following: Melt together equal parts of plate brass, bismuth, antimony and tin. Add the mixture at discretion to melted tin until it acquires the proper degree of color and hardness; or melt together 1 part of antimony, 4 parts of brass and 5 or more parts of tin. This may be used at once.

Plumbers and Plumbing.

The remarkable growth of towns and cities, the expansion of the facilities for the furnishing of light, heat and power, the enormous growth of manufacturing, the aroused interest in hygienic surroundings and the concentration of people and productive capacity within minimized space, together with some other agencies, have served to transform the once simple craft of plumbing into one of the most important industries. The progress of this important craft is indicated by the great variety of appliances and accessories, many of which are patented, and in great industries which have sprung up to supply plumbers' requirements.

Manufacture of Pipe.—The manufacturing of pipe has developed into an important industry. Cast-iron pipe, wrought-iron pipe, brass pipe, lead pipe and tile pipe are all used in plumbers' work. The fittings are variously designated. Such as Y, TY, and double TY. The common methods of making joints in lead pipe are known as the "cup joint" and the "wipe joint." Metal piping is chiefly used in buildings, but in solid earth, salt-glazed, vitrified or terra-cotta pipe are used for making connection with the main sewer.

Practice.—There is much divergent practice in the methods of connecting traps, and cities vary in their respective requirements. Siphoning is well understood and utilized at every point. Three methods are used to prevent destruction of seals by siphoning. The first is back-venting; second, to make the body of the trap so large that a sufficient quantity of water will always adhere to its side, after siphoning, to restore the seal; third, the use of a trap of such form that it will not siphon and be self-cleaning.

Tests.—The same general principles govern the plumbing of hotels, school-houses, railroad stations, office buildings, shops and factories. Two tests are usually applied to determine the correctness of the work; first, the roughing process, which applies to soil, waste and vent pipes, and is done before the fixtures are connected. The second or final test is made after the fixtures are in and is made in two ways, viz.: by the "peppermint test" and the "smoke test."

Hydraulics.—The science of hydraulics as to plumbing is all important. To this end, tables showing results of experiment and experience have been formulated, reference to which enables the proficient plumber to solve most problems with which he has to deal.

Materials Used.—Wrought iron, lead and brass are the principal materials used for water-pipes. Wrought-iron pipe is the cheapest and easiest to lay. Tin-lined lead pipe for domestic purposes is objectionable because of the difficulty in making joints. Brass is one of the best materials for hot-water pipes. The most common forms of pump used are known as the lift pump and the suction pump. The two methods for supplying a building with water are known as the "direct supply system," and the other, the "indirect" or tank system. The indirect is better for domestic purposes. In the indirect system each fixture is connected with the supply pipe and is under the same pressure as the street main unless a reducing valve is introduced. Most modern systems of plumbing include a hot-water supply. The boiler used in these systems is not a heater but only a storage tank and it is important that there be no sediment between the water-back and the boiler.

Gas Piping.—Gas piping in buildings is a separate branch of plumbing; cooking by gas has developed a number of economic appliances of great value, which have greatly modified minor housekeeping. The manufacture of gas machines has become an important and rapidly-growing industry and bears some relationship to the plumber's craft. The mechanical engineer of to-day, as well as the architect and builder, find it an absolute necessity to become, in a sense, a plumber, in order to meet the exacting demands of modern construction and the urgent requirements of municipal growth.

Plumbers' Tools.—The principal work of the plumber is directed to the making of connections for water and gas and in adjusting apparatus for domestic convenience and all hydraulic appliances required in habitations. The plumbers' tools may be roughly classified as knives, chisels, gauges, rasps or files and planes for fitting and jointing, dressing and flattening tools, hammers and mallets, ladles, a hand grate or stove, stock and bits for boring holes, rules of boxwood and of steel, compasses, lines, centerbits, weighing apparatus, etc. The material used is chiefly lead and solder.

Solders Used.—Among the ordinary solders used may be mentioned soft coarse, made of 1 part tin and 2 parts lead; soft fine, tin 2, lead 1; soft fusible, tin 2, lead 1, bismuth 1; pewterers', tin 3, lead 4, bismuth 2; soft spelter, copper 1, zinc 1; hard spelter, copper 2, zinc 1; solder for brass and iron, silver 1, brass 1. To solder tin, use coarse or fine soft solder and resin flux lead, soft coarse solder, with resin flux; to solder brass, copper, iron and zinc, use coarse soft solder with zinc chloride as flux; brass, soft spelter with borax as flux.

Coarse Solder, How Made.—Plumbers' coarse solder is made of tin 1 part, lead 3 parts, with resin as flux, fluxing point 800 Fahr.; plumbers' sealed solder, tin 1 part, lead 2, resin flux, fluxing point 441 Fahr.; plumbers' fine solder, tin 1, lead 2, resin flux, fluxing point 370.

Tinners' Solder.—Tin 1½, lead 1, resin or zinc, fluxing point 334 Fahr.; hard solder for brass, copper or iron, copper 2, zinc 1, or a solder of good tough brass 5 parts, zinc 1; silver solder for jewelers', silver 19, copper 1, brass 1; silver solder for plating, silver 2, brass 1; silver solder for silver, brass or iron, silver 1, brass 1; silver solder for steel joints, silver 19, copper 1, brass 1; gold solder is made of 12 parts gold, 2 parts silver, 4 parts copper; bismuth solder, 4 parts lead, 4 parts tin, 1 part bismuth, or 2 parts lead, 2 tin, 1 bismuth, or 3 parts lead, 5 tin and 3 bismuth.

To Solder Seams.—To solder seams properly, the old solder should be melted off, the old tin nicely retinned and strips of tin soldered over the old seam. The edges of the strips can be bent slightly in the locker, so that they will not spring up while being soldered.

A solder for sealing iron in stone is made of 2 parts lead and 1 part zinc. A good soldering liquid is made by cutting zinc into small pieces and dissolving in hydrochloric acid until the acid ceases to bubble. The acid is neutralized by ¼ part of the solution of ammonia added. This should be diluted with an equal quantity of water and it will not rust iron or steel.

Other Good Solders.—A good soldering paste is made by mixing starch paste in a solution of chloride of tin. There are numerous methods for cold soldering. One of the best methods of preparing such solder, which is somewhat tedious, is as follows: Take 1 part metallic sodium to 50 or 60 parts mercury, shake well in a bottle and well stoppered. It will amalgamate any metallic surface, even cast iron. Sodium amalgam can be purchased. A soft solder of great value is made of 2 parts tin to 1 part lead, which is applied with a hot copper bolt or blow-pipe flame.

Fluxes.—To prevent the heat oxidizing the edges of the metal, the edges are covered with a substance having a strong attraction for oxygen, which disposes the metal to unite to the solder at a low temperature. Such substances are called fluxes, and are chiefly borax, resin, sal-ammoniac, chloride of zinc, Venice turpentine, tallow or oil.

Zinc may be soldered as readily as tin by using dilute hydrochloric acid, $\frac{1}{3}$ its bulk of rain water added, as a flux instead of resin. Keep the soldering iron hot.

Cement.—A plumbers' cement is made of 1 part black resin, 2 parts brickdust finely powdered and thoroughly dried, to which the resin is added in a melted state.

Comparative Summary of the Plumbing, Gas and Steam Fitting Industry.

	1880	1890	1900
Number of establishments...	2,161	5,327	11,876
Capital invested............	$5,950,512	$29,335,247	$47,111,264
Wage-earners...............	9,684	35,457	53,916
Wages paid.................	$4,770,389	$21,915,314	$31,873,866
Value of products...........	$18,133,259	$80,905,925	$131,852,567

Pneumatic Machinery.

Pneumatic Tools.—The use of air as a motive power in a large and rapidly increasing number of mechanical operations is one of the latest advances in mechanism. The pneumatic process in the operation of tools and machinery consists in the compression of air and in the use of the resulting pressure to operate tools or other mechanical agencies. For this purpose there are compressors and motors, varying in size and capacity according to the power required and the kind of work to be done.

Classes of Work Done.—Tools are especially designed for operating pneumatic chipping, calking, riveting and stone-cutting hammers, drills, reamers, wood-boring machines, flue cutters, painting machines, straight lift and motor hoists, stone-surfacing machines and all classes of compressed-air machinery in machine shops, boiler shops, railroad shops, ship yards, stone yards and in bridge and building construction work. Compressors are used for transmitting natural gas, driving rock drills, coal cutters, pumps, locomotives, hoisting engines and other machinery in mines, tunnels and quarries; sinking bridge caissons, pumping water by compressed air and every other purpose for which compressed air is utilized. A pneumatically operated chisel, for instance, is pushed against the metal to be removed, and the applied power, acting on the interior mechanism, drives the chisel through the iron or steel to be removed.

The Motor.—The pneumatic motor consists of two double oscillating cylinders set at right angles in an air-tight case. There is no movable mechanism, as the oscillation of the cylinders opens and closes the ports. A small quantity of oil is kept in the case, so that the crank in revolving lubricates itself and dashes the oil on the valve seats, from which the air carries it through the inlet ports in sufficient quantities to thoroughly lubricate the pistons. The air ports are controlled by a balanced slide valve, which closes them when on a center and starts or reverses the motor as it may be turned to the right or left. The valve is thrown by a lever to which chains are attached of proper length to be within easy reach from the floor. When the lever is released the valve is self-closing. The air-supply is controlled and the speed of the motor regulated at the will of the operator. The cylinders are bored true, and are automatically adjustable to their valve seats, the adjustment being simple and made from the outside of the motor case. The piston rods are ground. The stuffing boxes are ample and contain sufficient packing for long wear. The cylinder trunnion bearings are bronze. The crank-shaft bearings and the crank connections are bronze bushed. The material used throughout is the best obtainable. Superior workmanship is required on all the vital details of construction.

Riveting Hammers.—With pneumatic riveting hammers two men and one heater can average daily (10 hours) 500 rivets, whereas by hand 250 rivets per day was a good day's work for three men and one heater. This is done by one air hammer only. The work is far superior to hand work, leaves less loose rivets, heads are invariably perfect, shank of rivet filling hole and the work in every way far exceeds the hand work. It seems useless to call attention to the benefit of reamed holes in assembling joints made by pneumatic drills over the "drift-pin work," so much in use where hand riveting prevails; but with the rapidity that air drills run the expense of reaming rivet holes has been reduced to a minimum. Improved hammers are free of vibration or concussion that had been somewhat of a drawback to the earlier hammers. In field work there were many difficulties when doing hand work that would cause delays that are now overcome quickly by use of air. In chipping, cutting out, reaming, drilling, etc., work can be done in a fraction of the time that it used to take.

Air Drills.—Piston air drills and reversible machines operated pneumatically, now in quite general use, are probably the highest evidences of progress along pneumatically-operated devices. These machines are of the "balanced" piston type, and consist of four single acting cylinders arranged in pairs, each pair of pistons being connected to opposite wrists of a double crank shaft; each piston of each pair travels in opposite directions at all parts of the stroke, thereby insuring a smooth running machine. The balanced piston valves are set to cut off at five-eighths of the full stroke, thus insuring great economy in the use of air without sacrificing speed or power.

Method of Action.—The crank-shaft revolves in an enclosed chamber designed to be kept partly filled with oil. All of the four cylinders open at the rear ends into this compartment, and the gear case also communicates with, and forms a portion of this chamber or oil receptacle. When the machine is in use the rapid rotation of the crank shaft throws the enclosed oil over the parts located in the chamber and in the gear case, thereby insuring perfect and continuous lubrication of all the parts. In these machines the exhaust air does not pass through the working parts, therefore there is no drying of the oil, as is the case with machines that exhaust internally. This method of exhaust prevents any particles of grit or dust contained in the air from getting into the working parts of the machine.

Pneumatic tools have revolutionized many machine-shop processes. The air compressors used are operated by hand, belt, gear, electricity, water-power, gas or by oil engines, and the types of machines used are single, straight-line engines, duplex, half duplex and compound.

Capacity of Compressors. — The air compressors are made of varying capacities, ranging from 95 cubic feet of free air per minute with 130 revolutions, to 750 cubic feet per minute and 150 revolutions per minute. Weights of compression range from 1,000 to 19,000 pounds. Exceptional sizes from 20,000 pounds to 65,000 pounds, in which latter case the capacity is 2,052 cubic feet of air per minute with 120 revolutions; weight of fly-wheel, 10,000 pounds; horse-power, 360.

Preserving Fruits and Vegetables, Art of.

Three Systems of Drying.—Nearly all the improvements relating to drying or evaporating fruits or vegetables fall within one of three classes: First, those in which the trays of fruit are placed upon stationary ledges within a heated chamber; second, those in which the trays of fruit are placed within a heated chamber and raised or lowered step by step by mechanical means farther away from or toward the source of heat as the drying progresses; third, those in which the fruit is placed in imperforate steam-jacketed pans.

Modified Improvements.—These three types of fruit driers form, under the present classification, the basis of the sub-classes—driers, shelf and tray, elevator and pan, and boiler, respectively. These processes have been known for over thirty years. Improvements have been made since then, but only in the direction of details of form, ventilation, methods of regulating heat, or moving the trays, but without marked change in structure or advance in efficiency.

Sterilizers.—A large class of devices has been brought into general use during the past thirty years, called "sterilizers." In some of these the receptacles are placed within the chamber, and by devices operated from the outside, the cans or bottles are opened or shut while within the steam-filled chamber.

Commercial Results. — These improvements have developed a great demand for fruits and vegetables which would not otherwise exist, by reason of the fact that these products are preserved in a condition which allows them to be marketed throughout the twelve months of the year. Their dietetic values have created a large and steady demand for them, and a great industry has been built up which simplifies housekeeping and affords ready-prepared foods for immediate use.

Comparative Summary of Fruits and Vegetables—Canning and Preserving.

	1880	1890	1900
Number of establishments...	411	886	1,808
Capital invested............	$8,247,488	$15,315,185	$27,743,067
Wage-earners................	31,905	49,762	36,401
Wages paid.	$2,679,960	$4,651,317	$8,050,793
Value of products...........	$17,599,576	$29,862,416	$50,668,313

Increase.—The use of fruits and vegetables dried or prepared for future use and readily available, has increased threefold within twenty years, and the number of establishments has increased over fourfold, while the number of wage earners has only slightly increased, because of the remarkable improvements which have been made in the manufacturing and handling processes. Household labor has been minimized by the supplies of fruits and vegetables now annually turned out in immense quantities. This industry has also given an impetus to the orchard and vineyard interests.

The almost doubling of the distribution of canned fruits and vegetables during the past decade and the practical doubling of invested capital indicate very clearly the future trend of the industry, both as to volume and variety of production. The elimination of kitchen duties and household responsibilities, stimulated by the "servant girl" problem, is calling for the greatest possible preparation of foods in factories and their distribution in convenient packages for consumption. This tendency is further stimulated by the economies effected through wholesale manufacture, the cheaper cost of material through wholesale purchases and the elimination of numerous middlemen's profits from garden and orchard to the factory. Perhaps no other industry in the United States has as great possibilities before it for expansion. Mechanical processes are being revolutionized in manufacturing. Purity of product is being increasingly assured.

Printing and Printers.

Origin of Styles of Type.—Italic type were first used in the year 1500; Greek type, in 1465; Hebrew, in 1475; Arabic, in 1514; Syriac, in 1538; Armenian, in 1591; Ethiopic, in 1513; Coptic, in 1636; Samaritan, in 1636; Slavonic, in 1491; Russian, in 1517; Etruscan, in 1713; Runic, in 1611; Gothic, in 1677; Scandinavian, in 1677; Anglo-Saxon, in 1567; Irish, in 1571. The earliest type of music type was seen in 1495. Printing for the blind was first introduced in 1784. Eshard Ratdolt, of Venice, in 1475 introduced wood-cut initials. Caxton introduced one or two kinds in 1484. Type ornaments and flowers, as fine as some made now, were used by printers in Holland between 1475 and 1490.

Art in Early Printing.—The early printers gave more attention to artistic effect, and the early binders to greater excellence from every point of view. Their work along both lines has been of late years copied or imitated. The early German, French and English printers excelled in some special features, but as soon as a commercial demand arose, old-time excellence was lost sight of and work began to be turned out as cheaply as possible.

The Cylinder Press.—For a long time the hand-press answered requirements, and it was enlarged from time to time until the limit was reached. Meanwhile, inventors were at work on the cylinder press, but it was looked upon with suspicion for fine work. The platen presses were reserved for this purpose. Soon experiments demonstrated the cylinder press was much quicker and more productive, and required for a given amount of work less driving power.

Kinds.—Cylinder presses are of two kinds, viz.: the cylinder and rotary. The single cylinder soon proved its great value and reduced the nine operations of the hand-press. The extra-color Bremmer machine was followed by the Marinoni, and that by the Water machine. At first the early inventors tried to use cylinders covered with leather, but composition rollers soon took their place. Through the recent improvements made, it has been found that the former habit of dampening paper to secure a good impression can be safely discarded.

Present Tendency to Early Art.—Artistic printing is now being revived in answer to demands for finer typography, and in the United States a vigorous impulse has been imparted to it, resulting in the production of books which, in points of typography and binding, compare favorably with the finest work of the early printers and bookmakers.

Subdivision of Work.—The subdivision of work which has accompanied the progress of printing has contributed to the excellence of work. To-day the work of composition is highly specialized. Job printing, book printing and a score of other branches have been developed to a high degree of efficiency. The modern printing establishment represents a complexity of appliances and devices and methods which would confound an old-time printer could he reappear.

Early Printing in America.—The first printing done in America was at Cambridge, by Daye, in 1639, who printed the "Freeman's Oath," on a press brought from England in 1638. In 1649 Samuel Green printed Eliot's Indian Bible on a press sent from England; in 1655 John Foster set up the first press in Boston; in 1674 and in 1690 Richard Pierce published a newspaper, which was afterward suppressed. The "Boston News Letter" appeared in 1704, and the "Boston Gazette" in 1719. The art of printing was introduced into Massachusetts and Pennsylvania earlier than in New York. William Bradford was induced by the New York State Government in 1693 to go from Philadelphia to New York to print "Acts of Assembly and Publick Papers." In 1725 he started the first paper there, the "Weekly Gazette."

The annual fairs and trade sales of books established in New York in 1802 by the American Company of Booksellers, stimulated printing. The establishment of the Harpers in 1817, and of the

Appletons in 1825, still further aided the industry.

Type Foundries and Presses.—Small type foundries soon began to appear to supply the early printers. A type-casting machine was invented in 1838 by Bruce, and by this process the cost of type was greatly reduced. The attention of inventive machinists was directed to the improvement and enlargement of presses, and one improvement after another followed in rapid succession.

The Advent of the Hoe.—When Robert Hoe, in 1853, invented the 10-cylinder press, it was declared by the Lords of the Privy Council of England to be "one of the greatest steps ever taken in printing," and doubtless it was.

The Mergenthaler Machine. — The first step successfully taken in machine composition was when Ottmar Mergenthaler, in 1886, introduced, after many years of effort, his Linotype machine, in which machine types have no existence. The unit is the line, which is known as a "slug." By pressing the keys, the operator assembles brass matrices, and on the completion of a line these are pressed forward against a bar of molten type-metal, casting the line or slug ready for printing. By continuation of this process the matrices return automatically to their receptacles.

Some Others.—The Lanston Monotype is a combination of a keyboard, by which a strip of paper is punched, and a machine casting individual types from matrices indicated by the passage of compressed air through the holes in the punched paper strip. The Godson Graphotype is a combination of two machines operated by electricity, and casts individual type. The Scudder Monoline, a Canadian machine, has its matrices located in a disk. Besides these are the Dow Composing Machine and the Simplex One-Man Type-Setter.

Art Development.—The art of printing is developing to higher excellence. Three styles have prevailed within the past twenty years. The first showed a great number of face type in all display work and on title-pages. The second style imitated ancient designs and type faces. The third style used the plainest type for titles and display.

Progress in Press Building.—The old cylinder press still holds its place, but its proud brothers deign scarcely to notice it. Let us note the steps of progress. The old-fashioned drum-cylinder press was evolved from the double-cylinder, which in turn was evolved from the cylinder. Then came the stop-cylinder press, which permitted more accurate feeding and did very good "registering."

The Web-Perfecting Press.—Hoe & Co., in 1871, introduced the first successful perfecting press; next came the perfecting of folding mechanism, by which papers of any number of even pages are turned out cut, pasted, folded and counted, at rates of speed varying from 12,000 to 150,000 an hour. In this press a roll or "web" of paper passes into the press, and is printed, or "perfected," on both sides before being cut or folded.

The Double-Supplement Press.—Next followed the double-supplement press; then the quadruple press, which, instead of being arranged side by side, the presses were often constructed with the supplementary press on top, making a double-decker. This was converted into a sextuple press, and it became a simple matter to convert this into an octuple press, which is sometimes constructed by piling four double presses one above the other.

Illustrated Supplements.—The illustrated colored supplements of the large city journals are produced by the adaptation of these presses to color printing, permitting the use of one, two or three colors besides black. This principle has been carried still farther in a rotary multicolor and half-tone machine, which prints in as many as eleven colors, and has a capacity of 48,000 full-sized 8-page papers per hour.

Two Classes of Web Presses.—There are two general classes of web presses. In one the "angle bar" turns the sheets in order to assemble them from the different webs. The other is known as the "straight line," the sheet being run through the press without being diverted from a straight course.

The Multipress.—In the Multipress perfecting press, the type beds are stationary and the cylinders roll back and forth upon them. These are adapted to country dailies. There are many variations of the perfecting press, to suit all manner of requirements. One press (the Goss) is fitted with an ingenious arrangement to prevent offsetting. Rollers made of molasses and glue pass over freshly printed paper, absorbing the excess of ink, which is then transferred to a polished cylinder, from which it is removed by a cylindrical cotton wiper. The perfecting presses are so improved that they are now used for fine magazine work.

Early Printing in Pennsylvania.—The first printing press in Pennsylvania was erected in Philadelphia in 1686, four years after the first English settlement was made in that colony.

Franklin was an established publisher of magazines and other periodicals in 1741. In 1760 it was estimated that a half million volumes were published annually in that city. The first Bible printed in the United States, excepting those printed in the Indian tongue, was from the press of Christopher Sour in 1743, and his descendants are still in the same business. The first daily paper in the United States appeared in Philadelphia in 1784, the "North American," which is still published. Shortly after the opening of the last century, 110 wooden presses were in operation in that city, a larger number than in any English-speaking city in the world, London excepted.

Early Newspapers.—By 1810, 73 newspapers had been successfully established in Pennsylvania, of which 8 were daily papers. In 1817 George Clymer, of Pennsylvania, invented a hand-press, which was introduced the following year into England, and remained in use until 1860. It was the first press built in the United States that printed both sides of a newspaper at once. Coming down to the past decade, in 1890 there were in that State 1,487 printing establishments, employing 15,000 men, who produced work valued at $34,408,483. In 1900 there were 1,795, which showed an increase of 6 per cent. in output in ten years.

Daily and Weekly Papers.—Dailies and weeklies sprang into being in New York, Boston and other Atlantic coast cities early in the century, stimulated by the aspirations of the people for news and knowledge. These early papers attracted the attention of the general public, and they became in a sense educators of public opinion, and grew steadily in circulation and influence. The discussion of political questions soon became a feature of daily journalism, and through it the voice of the people found effective expression.

The Latest Process.—The latest printing process is known as the Lithotype. Its action is based on the idea of using aluminum plates for all printing in which lithograph stones have been employed. The claim is also made that it eliminates all setting and distribution of type, as well as matrix making, stereotyping and electroplating. The plates are only one-thirty-second of an inch thick. As at present constructed, the Lithotype consists of two parts or devices operating separately.

Coördination of Parts. — Arrangements, however, have been made to coördinate these parts. The first consists of a small machine comprising a keyboard similar to the ordinary typewriter keyboard, perforating device to perforate a paper ribbon or strip of any required length, and a counting device. The perforating device is operated electrically and controlled by the depression of the keys.

Spacing.—The machine automatically takes care of the spaces between the words. The perforated strip goes directly into the second part of the combination, which operates to bring the printing member into position, so that the selected character is directly opposite the printing point. The character is then inked, the paper is moved up to the character, and the impression is taken therefrom. This action is repeated for each character until the line is completed, when the paper-carrying device returns and moves for the new line. The transfer thus obtained is now ready to be impressed on the surface of the prepared aluminum plate. The plate, with the imposed transfer, is put under pressure, the paper is washed off, the impression thus made is rolled up, and then, with a few finishing touches, is ready for the press.

Printing and Its Influences and Aims.—The printing art of to-day represents the struggles, toils and sacrifices of men who sought by type to broaden the character of the American people, to deepen their comprehension and to fit them for the work of maintaining and sustaining the principles underlying free government. The pioneers in printing, through their life-long devotion to the purpose of disseminating knowledge, sought to enlighten the people, as is shown in the character of publications which passed through their presses. They sought to educate the human mind out of the inherent errors of the past, and to open it to the stimulating influences of the present, and to elevate and broaden its conceptions and aspirations, that it might in greater measure feel the inspiration that precedes all genuine progress. The printers of America have been men who were animated with high ideals and who were imbued with high conceptions of religious and civic responsibilities. What America is, is in a measure due to the devotion to high standards of duty and high ideals of citizenship of its early printers, led by Franklin, Bradford and a score of broad-minded men who adopted printing as a means to reach the people.

A Comparative Summary of Printing and Publishing in the United States.

	1880	1830	1900
Number of establishments...	3,468	16,566	22,312
Capital invested............	$63,003,704	$195,387,445	$292,517,072
Wage-earners...............	58,506	136,836	162,922
Wages paid..................	$30,541,657	$78,810,319	$84 249,954
Value of product............	$90,970,341	$275,452,515	$347,055,050

Pulverizing Machinery.

Variety of Work Done.—The construction of pulverizing machinery has led to the development of an important industry in the United States. Mechanical appliances range from the giant ore crushers to the delicate devices for pulverizing materials for drugs and other refined products. The records of the Patent Office exhibit a vast array of pulverizing machines and devices, each an evidence of wonderful mechanical conception and ingenuity and skill in construction. The flour-milling industry, the rice industry, the crushing of cereals generally for further use, the pulverizing of ores, the crushing of stone, the grinding of coffee, the maceration of pulp for paper, the stamping of minerals for the extraction of valuable ores and a score or two of other uses, are all accomplished by these widely diversified mechanical appliances, and which are operated by hand-power, water, steam and electricity.

Feeding the Crusher.—The greater crushers or pulverizers are to be found in the mining industries. Roller crushers practically consist of two hard steel cylinders driven by gearing and kept in constant contact by means of strong India rubber buffers or by equivalent and more durable mechanical devices. The ore is fed between rollers which were formerly made of iron and were pressed together by means of levers and weights, which primitive process is still pursued in some localities. The modern roll crusher is driven by means of belt and gearing in conjunction with a fast and loose pulley. In some crushers used in certain parts of the world, India rubber springs supplant cumbrous systems of levers and weights. The feeding of large crusher rolls is to a degree regulated by the picking table above, so that the mineral arrives in a continuous stream of approximately equal masses, which fact adds to the effective crushing power. The working parts of crushers are shells made of chilled iron or steel. Most of the later American crushers embody patented improvements and devices which vastly increase their efficiency and their economic value.

Concentrating Machinery. — Concentration is the process of enriching ores and is divided into two general systems, coarse and fine, the choice of system depending on the nature of the ore to be treated.

The ores for coarse concentration are those whose minerals are in large crystals, masses or seams. Among these may be mentioned ores of lead, zinc, copper and iron.

The ores adapted to fine concentration contain the mineral in fine particles or crystals, disseminated through the mass of the rock in such a manner that a coarse crushing would leave the pieces of waste rock still impregnated with the mineral. Ores of silver, gold and tin are usually of this character.

Machinery for coarse concentration are stone-breakers, picking tables, roller crushers, sizing trommels, jiggers, classifying apparatus, fine jiggers and some form of buddle, table or vanner for the treatment of the slimes. The ore is crushed as little as possible and the formation of sands and slimes is avoided.

In fine concentration the ore is reduced at once to sand and concentrated by the same machinery as is used for the classification and enriching of the sands and slimes made in coarse concentration. In gold and silver ores the precious metals are extracted by amalgamation, where free, before concentration, but most ores require both processes.

Rock Crushers.—The success of the Blake machine as a stone and rock breaker led to the introduction of modifications and improvements now on the market; the industrial requirements of the day are very fully met by a variety of crushers representing highest possible achievement. The Blake-Marsden stone breaker varies in size from 4x2 inches to 30x24 inches at the mouth. In the Huntington mill the rolls, instead of being fixed on parallel shafts pressed together by buffers, are suspended vertically and crush by their centrifugal force.

Stamp Mills.—Machines for the purpose of pulverizing ore by means of stamps have been used for three or four centuries. The stamp mills of the West have been improved up until it would seem that the only increase of capacity is now in adding additional stamps. Many endeavors have been made to improve upon the stamp battery, but it is, perhaps, the most effective machine yet invented.

The Steam Stamp.—The important feature of the stamp battery is the steam stamp which works upon the principle of the steam hammer. Although the use of stamps is very general and the machine is popular, it is not the most perfect appliance for crushing gold quartz. The great desideratum is a machine that will liberate the atoms of gold from their matrix of quartz or other gangue without destroying them, just as the kernel of a nut is freed from its shell by the nut cracker. Some mechanical engineers are disposed to admit that no appliance has yet been invented which will stop short at this point. The steam stamp, acting on the principle of the steam hammer, running at the rate of 90 blows a minute, is capable of crushing fine, a quantity of 150 tons in 24 hours, and coarse, 230 tons in the same time, though some do more work.

A Defect of Machinery.—In stamping, except in the later machines, the atoms of gold are crushed up and flattened, and by the continued blows are beaten out into thin films into which the hard, stony particles are driven. The effect of this is that the gold is either so finely divided as to float away with the water, or that the flattened grains are hardened by the repeated blows and coated by a film of gangue or other impurity which effectually prevents their being attacked and retained by the mercury of the amalgamated plates.

There is another serious imperfection common to most pulverizing machines, and that is that after crushing the gold down to the requisite size they keep on crushing it down to the finest slimes. It is endeavored to obviate this drawback by keeping the mortar-box filled with water and its contents in motion. The coarse concentration of materials ends with the process of jigging, which is well understood.

The Mixer.—Among the devices used are the mixer, which breaks up the slimes with water, and the round buddle, which is a shallow circular pit formed in the ground. The great drawback to the round buddle is that no clean products can be made straight away. The mineral must be handled several times and the machine must be stopped when full and lie idle until empty. In some parts of the world a revolving knife buddle is used, and in some mines a wooden percussion table is employed, though this concentration was not continuous in action until the board at the top end of the table was removed.

Evans' Slime Table. — Evans' slime table has taken the place of the round buddle in many lolocalities, with capacity of 25 to 30 tons per day. In the process of fine concentration the Frue vanners are used to great advantage in mining localities, producing absolutely clean concentration, and with comparatively small loss.

An important feature of the vanner where it is used is that no sizing of the pulp or slimes is necessary. They pass direct from the stamps on to the copper plates, if these are used, and thence to the vanner.

The Embrey Concentrator. — The Embrey ore concentrator obviates the side shake which is the peculiarity of the Frue vanner. This is replaced by an end shake of from 200 to 220 per minute.

The points to be regarded in the concentrator are perfect regularity in feed, in speed, in supply of water and perfect cleanliness of machine.

The conduct of the various washing processes employed in the concentrations of ores, lead, copper, zinc and tin require constant watching to prevent losses, not only by the carrying away of mineral matter but also from enriching the mineral beyond the economic point at which concentration must cease.

Assay.—It is of importance to maintain a system of sampling and assay, to be regularly followed throughout the various machines, from the rock breaker down to the last process. It is well to sample the crushed ore as it passes from the first rolls, or stamps, to the first series of trommels, either automatically or by a machine or by hand.

The question of improved concentrators has been recently pretty well answered by the progressive improvements of mining-machinery makers.

Pumps and Pumping.

Mine Pumps.—In mining operations the duplicate pumping system is used to secure uninterrupted action of pumping. The pumps mostly used are the Worthington, Deane, Knowles and Cameron. The principal features of construction may be enumerated in the Worthington: The water plungers are double-acting, working through exterior stuffing-boxes and adjustable packing, the suction being at the lower end of the pump. There is an entire absence of concussive action. With an injection condenser, the momentum of the incoming injection water and exhaust steam is employed to assist the pump in maintaining the vacuum in the condenser. In all types of condensers and air pumps the valve motion prevents noise and concussive action. The two pumps, being side by side, act reciprocally upon the steam valves of each other. One piston acts to give steam to the other, then furnishes its stroke and waits for its valve to be acted upon before it can renew its motion. This allows all the water valves to seat quietly. There is no dead point, the pump therefore being always ready to start by simply opening and shutting the throttle valve.

The Pulsometer Pump.—In the pulsometer the hollow chamber consists of two pear-shaped castings forming water chambers. There are only five moving parts—the steam-admission valve, the two suction and two delivery valves. This pump will raise water 80 feet and higher. Triple-expansion duplex-station pumps are largely used in mines, and are often preferred to high-duty pumps, especially in deep mines.

Use in Mines.—The centrifugal pump is largely used at mines where muddy water has to be dealt with, but it is available only for moderate lifts, and should be placed not far from the surface of the water to be raised. The joints of the suction pipes must be perfectly air and water-tight.

To Calculate Power.—To ascertain the horse-power required to do a given amount of work in pumping, take the quantity to be raised in a unit of time, and the height to which it is to be raised; reduce the quantity to pounds raised per minute, this multiplied by the height in feet, and the product divided by 33,000, gives horse-power.

Application.—A gallon of distilled water, at 60 degrees Fahr., weighs 10 pounds. By adding a cipher to any quantity expressed in gallons, its weight in pounds is obtained. What horse-power is required to raise 500 gallons of water per minute 200 feet?

$$500 \times 10 = 5{,}000 \times 200 = 1{,}000{,}000.$$

$$\frac{1{,}000{,}000}{33{,}000} = 33\tfrac{1}{3} \text{ horse-power.}$$

Classification of Steam Pumps.—Steam pumps may be classified as hydraulic-pressure pumps, steam and power-crank pumps, direct-acting steam pumps, duplex pumps, compound direct-acting steam pumps, fire pumps, mining pumps, rotary pumps, centrifugal pumps and high-duty pumping engines, direct acting.

Hydraulic-Pressure Pumps. — Hydraulic-pressure pumps are now generally employed in riveting, shearing, punching, bending and flanging machines, for handling Bessemer converters, lifts and cranes in rolling mills and steel works, in shipyards and boiler-making works, at pressures ranging from 500 to 2,000 pounds per square inch, though in emergencies double this latter pressure is available. Hydraulic-pressure pumps are almost always fitted with double-acting plungers working through stuffing-boxes at each end of the pump barrel.

Steam and Power-Crank Pumps.—Pumps of this type are not so largely used in the United States, owing to the use here of the steam-thrown valve. They are compact, efficient, and are constructed at a low cost. A higher piston speed can be had with a crank and fly-wheel pump than in a direct-acting pump, because in the direct-acting the termination of each stroke is secured by steam acting as a cushion to counteract the force of the moving parts of the water to bring them to rest.

Direct-Acting Steam Pump.—In this pump the water and the steam ends are centrally in line with each other, so that the water plunger and the steam piston can be attached to the same piston-rod, both working together without the intervention of a crank. This is the simplest and most compact form of the steam pumping engine.

Valve Motions.—In the Knowles valve motion an auxiliary piston works in the steam chest and drives the main valve, and this chest piston is driven backward and forward by the pressure of the steam, carrying with it the main valve, which in turn gives steam to the main steam piston that operates the pump.

In the Cameron valve motion steam is admitted into the steam-chest, and through small holes in the ends of the plunger fills the spaces at the ends of the port. The valve motion is continuous.

In the Blake valve motion a supplemental or valve-driving piston is introduced to shift the main valve from its central position, in order to admit steam in front of the main piston. The main valve is divided into two parts, and by this simple arrangement the pump is rendered positive in its action, or, in other words, steam is always admitted in front of the piston just before it reaches either end of the cylinder.

In the Clarkson valve motion the motion of the steam-distributing valve is automatic, and is without eccentrics, tappets or valve gear of any kind.

In Dean Brothers' valve gear the motion of the auxiliary steam slide-valve is continuous; there is no "blow-through" or waste of steam in case the chest piston becomes worn.

In the Davidson valve motion the valve is moved both by direct steam pressure and by mechanical connection with the main piston-rod of the engine.

In the Marsh valve gear the movement has no external mechanism, the movement of the steam-actuated valve being controlled by the movement of the steam piston, and conversely.

In the Guild and Garrison valve motion the final stroke of the main valve is effected by a difference in steam pressure. The greater part of its movement is mechanically controlled by the steam piston.

The valve gear with cataract has five ports, the two outer ports being for steam and the three inner ones for exhaust.

The slide-valve has no lap or lead on either steam or exhaust sides, hence a steam and its corresponding exhaust port are open from end to end of the stroke. When desired, the compounding single direct-acting pump may be arranged for using steam expansively by the addition of a low-pressure cylinder tandem to that of the high.

The Duplex Pump.—This is an ideal pump in simplicity, and is the invention of the fertile brain of Henry R. Worthington. It consists of two steam pumps of equal dimension, placed side by side, with the valve motion so designed that the movement of the steam piston of each pump shall have the controlling movement of the slide-valve of its opposite pump. The effect of this is to allow one piston to proceed to the end of the stroke and gradually come to a state of rest. During the latter part of this movement the opposite piston then moves forward in its stroke and gradually comes to a state of rest.

Dash-relief valves are valves used in large cylinders, at their ends, between the steam and exhaust ports. They regulate the cushioning and slightly lengthen the stroke after the piston has closed the exhaust port.

Lost Motion.—Lost motion results in the final adjustment of the slide-valve travel, and is a convenient method to equalize the length of the stroke of the steam pistons on the two sides of the duplex pump.

Compound Direct-Acting Steam Pumps.—These pumps utilize the heat wasted from the exhaust. In these, the steam pressure is the same from end to end of the stroke. Non-condensing compound steam-ends are economical under 65 to 100 pounds boiler pressure, the gain over ordinary-acting cylinders being from 20 to 35 per cent.

Fire Pumps.—Fire pumps, as now built, conform to specified requirements of the Associated Factory Mutual Insurance Companies. These pumps need more strength and better workmanship than others. Their capacity depends on speed. The air chamber is larger than on other pumps, and is tested to a hydraulic pressure of not less than 300 pounds per square inch. It has brass plungers instead of cast iron, bronze piston-rods and valves instead of iron, area of water valves is 25 to 50 per cent. greater than other valves, steam and exhaust passages 20 to 50 per cent. greater, and suction-pipe connections 2 to 4 inches greater in diameter.

Mining Pumps. — The metal used for mine pumps is almost always hard cast iron, with a gun-metal water end, or an extra thickness of iron often answers. Duplex mine pumps, because of their duplex valve movement, are largely used. For lining, wood is preferred to gun-metal.

Rotary Pumps.—Rotary pumps may be divided into two classes, according to the methods of working the pistons or those parts that act as such. Most rotary pumps are noisy, wear out rapidly, are costly to repair and do not have a high efficiency to begin with; but, nevertheless, they are very useful. The two objections to this pump are the inertia of the water and the necessity of imparting at certain moments a high velocity to a considerable mass of water.

Centrifugal Pumps.—A centrifugal pump consists of a revolving fan, having two or more blades, either straight or curved, attached to a strong revolving spindle, and fitted in a case or shell so constructed that the suction shall enter at the center of the wheel and the delivery placed tangent to the outer path of the revolving blades. In the centrifugal pump the main object is to pass the water through the pump with as little "whirling" velocity as possible. The passages through the pump must be so proportioned as to have a gradually increasing velocity in the water until it arrives at the circumference of the fan, and then to have a gradually decreasing velocity until it issues from the discharge pipe. To this end there is a conical end provided for the suction pipe, and a spiral casing surrounds the fan. The faster the fan rotates, the lift remaining constant, the smaller is the centrifugal force.

A remarkable property of the centrifugal pump is, a small increase in the number of revolutions of the pump when it has begun to discharge, produces a very large increase in the delivery.

Double-suction pumps are preferred to side-suction pumps where there is a suction-lift of several feet.

High-Duty Pumping Engines. — The secret of high duty of this class of engines is due to the design and construction of the steam engine portion of the machine, the use of high initial pressure, and the advantages secured by a liberal steam expansion in two or more cylinders. The degree of refinement to which steam-engine design has been carried seems to leave but little more to be accomplished in this direction.

Railroads and Railroaders.

The railway system of the United States, the grandest, most extensive and most complete in the world, has been built up practically within sixty years. The influence of this system upon the people of the United States is beyond estimate. By reason of the opportunities developed through railroad construction, vast potentialities have become realities, vast activities and vast wealth have been developed, and agencies have been organized and stimulated into vigorous life which have transformed the country from a comparative wilderness into a land of capabilities which point it out as the domineering factor in the world's development.

Mileage Increase.—There were 23 miles of railroad in operation in the United States in 1830. The mileage at the last report of the Interstate Commerce Commission was:—

The mileage by decades was as follows:

1840	2,818
1850	9,021
1860	30,626
1870	52,922
1880	93,262
1890	166,654
1900	194,321
1902	195,561
1903	199,481
1904	209,000

Averages.—The average number of miles of line to 100 square miles of territory has been 6 for the past decade, and the number of miles of line per 10,000 inhabitants 26. There is another way of putting it, viz.: If all the people in the United States were stationed along all the railway in the United States, they would be 13 feet apart.

Amount of Travel.—The amount of traveling done per head of population is gradually increasing, the increase in the last fifteen years being a little over five miles per year. The present average number of miles traveled, averaged up between the entire population, is about thirty miles, an increase from twenty-five miles fifteen years ago per year.

Passengers Carried.—Since 1890 the number of passengers carried has increased from 520,439,082 to 584,695,935 in 1900; the number of miles traveled by passenger trains increased in this period from 12,521,565,649 to 16,313,284,471, or approximately 25 per cent. The fares paid increased during this decade from $272,320,961 in 1890 to $331,402,816, or a little under 25 per cent. The average amount paid per passenger per mile was, in 1890, about 2$\frac{1}{5}$ cents (2.174 cents), and in 1900 a trifle over 2 cents (2.031 cents).

Cost of Travel Per Passenger.—Taking the cost of all the tickets bought, and dividing the amount up among all riders, it is found that the average ride per passenger amounted, in 1890, to about 52 cents (52.13 cents), and in 1900 to about 56 cents (56.67 cents).

Average Receipts Per Mile.—The average receipts per mile of railroad from passengers in 1890 were $1.724, and in 1900 $1.730, the average number of persons carried per mile of railroad being, in 1890, 3.294, and in 1900 3.053. The average number of passengers per train mile in those years was, respectively, 42 and 43. The average distance traveled per passenger in 1890 was about 24 (24.18), and in 1900 about 28 miles (27.90).

Freight Traffic.—The freight trains on the railroads of the United States covered, in 1890, 691,344,437 miles, and in 1900 1,071,431,919 miles, an increase of mileage approximately in the ratio of 7 to 11, although there was an increase in mileage during that time of nearly 25 per cent. The increase in the volume of freight was about double the increase in mileage.

Miles of Freightage. — The freight carried in 1890 passed over 79,192,985,125 miles, and in 1900 141,162,109,413 miles, or nearly double. The amount of freight paid in 1890 was $734,821,733, and in 1900 $1,052,835,811, an increase of 43.8 per cent. Prior to 1890 the average freight per ton per mile averaged about 1 cent; about 1890 a declining tendency set in, and in that year the average rate fell to .92 of a cent per ton per mile. By 1900 it had declined to .74 of a cent. The average amount of freight paid by each ton of freight carried one mile was, in 1890, $1.07. Each mile of railroad in the United States yielded from its freight traffic $4,651 in 1890, and in 1900 $5,498.

Freight Per Mile.—The average number of tons of freight carried per mile in 1890 was 4,376, and in 1900 5,595. The average number of tons carried on each freight train per mile was, in 1890, 164, and in 1900 275. The average distance which each ton was hauled was, in 1890, 114 miles, and in 1900 132 miles.

Interest Charge. — The interest paid on the bonded indebtedness increased from $224,495,571 in 1890 to $244,447,806 in 1900. The amounts paid annually for interest on bonds ranged between these aggregates.

Dividends.—The amount of money paid as dividends amounted, in 1890, to $83,575,705; in 1900, $140,343,653. The dividends paid in 1890 averaged, per mile of road, $511, and in 1900 $720.

Expenses.—The relation of expenses to earnings has been practically stationary; out of every $100 earned in 1890, $68.50 went for operating expenses, and in 1900, $68.93.

Financial Conditions.—In 1890 the capital stock of the 163,359 miles of railroad in the United States was $4,590,471,560, and in 1900 $5,804,346,250; bonded debt in 1890, $5,055,225,025. This shows an increase during that decade in capital stock of practically 25 per cent. and an increase in bonded indebtedness of practically 20 per cent.

Gross Earnings.—The gross earnings of the railway system in 1890 was $1,086,039,735; in 1900, $1,501,695,378, an increase of 39 per cent. over 1890. Net earnings increased from $342,071,296 to $493,247,526, an increase of 44 per cent.

Casualties.—By reason of greater caution on the part of passengers and additional precautions of railway companies, and by reason of the very general adoption of safety appliances in the way of automatic couplers, better signaling apparatus and the use of the block system, casualties have been very materially reduced when compared to the increased volume of passenger traffic and the increased number of trainmen and yardmen.

Killed.—In 1892 the total number of killed was 3,026, and total number injured 34,958. Of those killed, 100 were passengers killed in accidents to trains and 1,703 were injured. The following tabular statement will indicate the total casualties for the years mentioned:

	1892		1902	
	Killed.	Injured.	Killed.	Injured.
Passengers in train accidents	100	1,703	167	3,586
Other causes	199	1,526	136	2,503
Employés in train accidents	525	3,008	697	5,046
Falling from cars	644	3,780	537	6,867
Overhead obstructions	73	444	104	1.070
Coupling accidents	433	11,277	143	2,113
Other causes	1,052	13,220	1,035	18,615
Total passengers and employés.	3,026	34,958	2,819	39,800

These figures show that one person was killed in 1890 for every 60 miles of road and one injured for every 5 miles, while in 1900 the rate was one killed for every 65 miles of road, while the average mileage per injury remained about the same.

Speed of Trains.—A number of railroad companies have reached at times a higher speed than 60 miles an hour. Among them may be mentioned New York Central, 68.73, but which has reached 100 miles on a short stretch; Camden and Atlantic, 87.8 miles; Pennsylvania Railroad, 90 miles, with three cars and no stops; Philadelphia and Reading Railway, 82.73, on spurt for 12 miles, no stop; Baltimore and Ohio, 75 miles an hour for 7½ miles; Central Railroad of New Jersey, 97.3 for one mile; New York Central and Harlem, 102.8 for one mile, four cars; Lake Shore and Michigan Southern, 92.3 miles for one mile, and 72.91 miles between Erie and Buffalo, a distance of 86 miles.

Higher speeds have been announced, though not officially verified. The general tendency is to higher regular speeds, and if a summary could be made, it would doubtless appear that there is a gradual increase in speed of passenger and freight-train speeds.

Improvements in Tracks, etc.—The traffic demands are reaching such colossal proportions that it is becoming a commercial necessity, as well as of economy for the railroad companies, to expend vast sums of money in better ballasting of roadbeds, in straightening curves, in lowering grades, in tunneling hills and mountains, and in the construction of bridges which will permit of uninterrupted speed. In this respect the tendency is to stone and concrete. While the need of transcontinental lines and lines of great length is declining relatively, the necessities for reducing the rail distances between intermediate points is increasing.

Shortening Distances.—Very much more money is now being expended on shortening distances and in making other improvements to reduce operating expenses. A fever of improvement is abroad which is rapidly transforming the railway system of the United States from more or less primitive construction to ideal finish in accordance with the teachings of experience and practice. Nearly all railway systems are either borrowing money to prosecute improvements and expansion along these lines, or are using up all their available resources to consummate these purposes.

Equipment.—Every department of railroad service is being reorganized and improved. Railway equipment and appliances are being evolved according to more scientific methods, in which inventive ability is active. Personal observation, experience and study of responsible subordinates in all branches of the service are encouraged, and they are rewarded by promotion or by opportunities for advancement on other lines than their own.

Engine Capacity.—Under the stimulus of requirements for greater efficiency and capacity, all lines of service are being improved. Locomotive capacity is being improved and engines of phenomenal power are now hauling trains of 500 tons and over at increasing speeds over grades. Steel cars are supplanting wooden cars and of greater tonnage. Quicker methods of handling freight at various distributing points and terminals are being introduced. Better construction of trucks and wheels is appearing. Car detention is being reduced, so that the active life of rolling stock is being increased and greater speed in transit is being successfully worked out.

Automatic Systems.—This progress is accompanied by practically automatic systems for the safer running of trains through block-signal systems and various devices for greater safety, which reduces the personal factor to a minimum. Methods of communication are also being perfected, and systems are being established which centralize control and direction.

Some of the devices invented for use upon railways are exceedingly practicable as danger signals, but why they are not generally adopted is one of the things that are not easily understood. One of them is a torch which is attached to a pointed rod easily driven into a tie to keep it upright. By unscrewing a friction cap on the torch itself a bright red light, which neither rain nor wind can extinguish, burns for fifteen minutes, and is visible for one mile, making it unnecessary to send a brakeman back with a red flag.

Morals of Employés.—The morale of employés is improving under the innate feeling which stimulates each to do his best. The Young Men's Christian Association is becoming an important auxiliary, and provides means for intellectual improvement and social intercourse, the influence of which is good. The organization of associations which provide for support for retiring employés after reaching an age limit, is growing, and promises to become general when the wisdom of such effort is more generally recognized.

Respectability and Ability.—The railroad service has developed a class of citizens of marked capacity and ability. It has perhaps more than any other calling established the principle that merit and character are the sole means by which progress is possible. Men feel that their future is largely within their own control, and they are thereby stimulated to be honest to themselves and their employers, and to look to worth rather than to favor as the stepping-stone to greater usefulness.

World Systems.—The railway system of the world is estimated at a mileage of 400,000 miles, in round figures. Over one-half is in the United States and Canada. The yearly additional mileage, taking a decade, averages probably from 5,000 to 8,000 miles. During the period of the construction of transcontinental roads the mileage for a few years in the United States exceeded 10,000 miles per year. For some years past the mileage has ranged in and around 3,000 miles, not including sidetracking and repairs.

World Projects.—Railroad construction is in progress throughout the world, and from present indications we are on the eve of the greatest era of railroad building ever witnessed. A road is now being constructed across the empire of Africa from Cairo to the Cape of Good Hope, known as the Cape to Cairo Railway. A railway has been projected in the Western Hemisphere in which the North and South American republics are interested, which is designed to connect the most northern habitable sections of North America with the most southerly habitable sections of South America. For decades this project has been a dream, and to some enthusiastic projectors at times a nightmare. In due time it will be a glorious consummation under the irrepressible spirit of the American people, who propose by railway construction to place within the grasp of the people of South America those grand agencies by the use of which they can rise into a higher and more general civilization.

The Great Russian Road.—Other grand railway systems are projected, and one has just been practically completed under the genius of the Russian Government. It has opened up Siberia from Northern Europe to Eastern Asia. Other branches of this mighty trunk line are now under construction southward into Southern Asia and traversing Central Asia, opening up vast regions for the better use of man than the wandering barbarous tribes have known how to use. Railway lines are under construction, and others are projected in Southeastern Europe, into the countries which are termed the cradle of humanity, and those vast and neglected sections of the world will soon have placed at their command those inspiring facilities to effort which have contributed so much to make Occidental civilization a mighty power.

Equipment Industry.—The equipping of railways with motive power and rolling stock has built up one of the greatest industries in the

United States. The building of locomotives and cars, the manufacture of steel rails and track material, the building of terminal facilities and stations, the establishment of telegraphic lines and latterly telephonic connection, all unite to represent a spirit of enterprise and an industry of colossal magnitude.

Extent of Locomotive Industry.—The locomotive-building industry is now capable of turning out some ten or twelve engines a day, representing an annual output of 3,000 to 4,000 engines, ranging from $8,000 to $15,000 each. These engines are built capable of drawing trains of a weight of 500 to 2,500 tons, at a speed ranging from 30 to 60 miles an hour. The locomotive engine from one point of view represents the highest achievements of human skill. It is the embodiment of a thousand patents, and represents the concentrated energy of thousands of lives of skillful mechanics and inventors.

Car Building.—The massive passenger cars and Pullman cars represent the acme of achievement in car construction. The construction of steel freight cars, a new industry within the past decade, has assumed enormous proportions, and these steel cars are gradually supplanting the old cars of wooden construction because of their greater capacity, endurance and economic value.

Freight-Car Building.—Radical changes in the rules governing the construction of regular freight cars and coal barges have been made recently. This is in the nature of increasing the standard sizes of these cars. This is controlled by the Master Car Builders' Association, the recommendation of this body governing the cars used.

In a word, these cars are now constructed on standard lines with decreased length and increased height. The standard box freight is now 40 feet in length, with 80,000 pounds capacity. The standard coal barge is now 28 feet long, 80,000 pounds capacity, with the sides increased from 36 inches to 60 inches, or 5 feet.

Under former conditions some of these cars were 50 feet in length and only 60,000 pounds capacity. Not only were they unwieldy, but their length, with the heavy weight—although 20,000 pounds under the capacity at present—displaced the timbers and made them sag. Added to this, these cars took up space that is now saved. It will be readily seen that, with this decrease of 10 feet to the car, almost the full length of a car is made up in every four of the new dimensions. This is a great saving not only in storing space, but also a convenience in the matter of switching. With the additional height the car loses nothing of its capacity, but on the other hand, gains just 20,000 pounds to the car, and is better capacitated to carry the 80,000 pounds than was the old car to carry 60,000 pounds. This change in the standard size is meeting with universal commendation, and it is a certainty that the old-time long cars will be gradually discarded.

Safety Devices.—The devices and systems and methods which have been developed by experience, skill and ingenuity, are truly surprising. Automatic methods for regulating speed, checking the momentum of trains by air-brakes, automatic devices for switching, devices for indicating clear track or danger, and a score of other devices for the safety of the public, are high evidences of the enterprise and skill of American mechanism. These various systems, all focusing in protection, comfort and economy, have been perfected to a degree which reduces the danger of traveling to a minimum.

Branches of the Service.—The organization of the railway system has resulted in the division of labor into a great variety of branches of service, each branch having its own defined duties and responsibilities, and all acting in perfect harmony to insure the most valuable service. Systems of inspection have been organized by which the efficiency of the entire railway service is kept at the highest point. Methods of manufacture of equipment have been instituted which secure to the railways the very best material for their use. While the general divisions of the service may be classified into the carrying of passengers and of freight, these two general branches are necessarily divided up into many minor branches, each and all responsible to supervising heads.

Tendency to Centralization.—There is a natural and a healthy tendency to a centralization of power, which is wisely guarded by statute, and which prevents the consolidation under one management of parallel lines. Within these limits railway systems have been built up representing a total mileage of from ten to fifteen thousand miles each and beyond; these combinations create friendly understandings, by which a coördination of effort is developed and a spirit of harmony has been worked out which practically reduces the railway system of the United States to the control of comparatively a few heads. Public opinion is apprehensive of evils from this centralization, but recent experience has shown that, with wisdom among lawmakers and with integrity animating the course of justice, the people need fear no harm from these mighty centralizations.

Mileage and Rolling Stock.—The railroad track laid in 43 States and Territories in 1903 stretched 5,723 miles, bringing the total mileage up to 209,855. Notwithstanding the addition of the 5,152 locomotives and 155,097 cars built in 1903, and the 164,547 cars and 4,070 locomotives constructed in 1902, to the previous enormous railway equipment, the prolonged traffic congestion at certain periods in recent years has severely taxed the railway transportation system.

This condition of things is responsible for the question whether the domestic commerce of the United States has not demonstrably outgrown the distributive system of the country. We have had ten years of practically stationary railway mileage in the heaviest freight-producing sections of the country. There is a growing conviction among commercial organizations that, taking the centers of trade as a whole, there are many localities which are now less acceptably served than they were five or ten years ago.

Latest Welding Process.—During 1903 no less than 20,000 track-joints were made by the Thermit welding process. The system has been introduced in the cities of Leeds, Glasgow and Nottingham, and an English company is using the process for welding twenty-five miles of rails in Singapore.

For the welding of wrought-iron pipes the Thermit process has been largely used, between 30,000 and 40,000 joints having been made by it. This method is cheaper than the usual flange-joint, and is of special value for pipes or tubes under high pressure, or for the transportation of liquids, such as alkalies and petroleum, which attack the materials commonly used for packing.

Ranges, Heaters, Grates, Stoves.

Early Stoves.—The manufacture of ranges, heaters, grates and stoves forms one of the greater industries in the United States. Stove manufacture developed in the earliest history of iron making. Benjamin Franklin was the first to lay the foundation for the stove industry as we find it to-day. The stoves of his time lacked only in workmanship and artistic finish, but were highly serviceable and attracted the attention of the early mechanics to the possibilities of stove making. Foundries were soon established, in which were constructed stoves of great utility, on which improvements were made from time to time. Stoves on the continent of Europe have for a long time been made with a double casing surrounding the fuel chamber, into which air is admitted. These stoves are generally of earthenware, and are made round or square, and frequently constructed of tiles.

Heating Apparatus.—Heating apparatus is now constructed to use hot air or steam. Some use gas as fuel. The system of constructing hot-water flues and pipes has been developed to a high state of efficiency, and the industry is being strengthened by the introduction of new processes covered by patents.

Grates.—Grates were originally the universal method of heating. They are now made in multiplied form for the use of wood, fuel and gas, and are produced in a variety of artistic forms. Fundamentally, the grate is a partition or screen made of bars fixed parallel or at right angles to each other with interstices. This primitive style of grate has practically disappeared, and the numerous substitutions permit of the use of many varieties of fuel and add to the attractiveness and comfort of the home.

Systems of Heating.—Modern methods of heating, however, have widely departed from the primitive devices. Systems of construction call for heating on a more extended scale, and along scientific lines wherein the art of the machinist and inventor is permitted to manifest itself. Among the important improvements are appliances for the conduction of heat, generated in large furnaces, long distances through walls and partitions, walls or ceilings, by means of pipes of carefully calculated diameter.

New Systems.—Mechanical engineers, under the stimulus of broadening opportunities and necessities, are bringing out new systems, or at least modifications of older systems, by which more efficient services are rendered at decreasing cost. Complete as are the devices and appliances, there is still room for further improvements which the changing methods of construction and the increase in the size of buildings permit and demand. The magnitude of the industry cannot be specifically indicated, by reason of the fact that the production of these means for heating are conducted in plants, the output of which is included in other products.

The establishment of large and highly equipped foundries and plants with special mechanical appliances has done much to stimulate the use of these modern scientific methods of heating.

Regalia Making.

By Whom Originally Worn.—Regalia making has become an important industry under the remarkably rapid development of the spirit of fraternity among the people. Originally the right or privilege to wear regalia was confined to sovereigns by virtue of their office, but the permission to wear it was gradually extended to the nobility, to whom its real significance, whatever that significance is, is mainly confined. Regalia in the latter ages came to be worn by the judiciary, by the military and by those high in station. It was used in an emblematic sense, and in its production the highest art of the early workmen was taxed to produce garments or trimmings of fine texture, superb workmanship and great artistic beauty. Each of the royal families of Europe have their distinct regalia as regal symbols.

Regalia of the English King.—The regalia of England is kept in the jewel room of the Tower of London, and consists of the crown, sceptre with the cross, the verge or rod with the dove, the so-called staff of Edward the Confessor, several swords, the ampulla for the sacred oil, the spurs of chivalry, etc. The regalia of Scotland, which is preserved in the Castle of Edinburgh, consists of the crown, sceptre and sword of state.

Extension of Use.—With the rise of Freemasonry the use of regalia became more extended, and with development of more modern orders, its use gradually became common as insignia of office. Regalia is now used by nearly all the secret and fraternal orders, the membership of which runs into millions.

Its Manufacture.—The business of manufacturing regalia has become quite an important one, in which silk is an important raw material. Gold, silver and other precious metals are used in the manufacture, with silk and other fine textiles. Some of our modern regalia is highly artistic, extremely costly, and superior in workmanship to most of the regalia of earlier times.

Banners and Emblems.—The manufacture of emblems and banners, one of the branches of the regalia industry, is becoming an important industry, and from the same cause which has brought regalia into demand. Most secret orders have their banners of silk or other finely woven textile material, in which the workmanship represents the highest skill and art, as well as the designing ability of the textile worker. The extent of the industry is indicated by the fact that there are 120 establishments in the United States at the present time engaged in the manufacture of all kinds of regalia and banners, which have a wholesale value of between three and four million dollars. The industry affords employment to some 1,500 men.

Early Mention. — In regalia making gold and silver were used from earliest times. The first mention made in sacred writings is in Exodus, chapter 39, verses 2 and 3, concerning the ephod made for Aaron, wherein the record is, "And he made an ephod of blue, green and purple and scarlet and fine twined linen. And they did beat the gold into thin plates and cut it into wires to work it in the blue and in the purple and in the scarlet and in the fine linen with cunning work." The Iliad and the Odyssey speak of embroidered gold textiles. Josephus says Herod on the day of his death wore royal apparel which was a tissue of silver.

Fabrics. — Fabrics woven with gold and silver continue to be made to this day in India into laces, brocades and embroideries, from whence the art has been introduced into Europe and to a marked extent in the United States. The various qualities of wire are prepared precisely as in India—round and flat—and thread, made of flat gold wire is twisted around orange-colored silk or cotton, known in the trade as "orris." The lace is woven in the same manner as ribbons. Cloth of gold and brocades rich in gold and silver are woven for ecclesiastical vestments and draperies and for vestments for officers in various secret orders and for badges and insignia. Some gold wire is exported to China and India.

Wire Basis.—The metallic basis of the various fabrics is wire, round and flattened, the wire being of three kinds: First, gold wire, which is invariably silver gilt wire; second, copper gilt wire, used for common liveries and theatrical purposes, and, third, silver wire, all of which are drawn by the ordinary process and flattened between a pair of revolving rolls of fine polished steel.

Composition.—Very little gold is used. An ordinary gold lace wire is drawn from a bar containing 90 parts of silver and 7 of copper, coated with 3 parts of gold. Each ounce Troy of a bar so plated is drawn into 1,500 yards of wire. Sixteen grains of gold cover a mile of wire. About 200,000 ounces of gold wire are annually worked up in the gold lace trade in Great Britain.

Regalia in America.—The manufacture of regalia and material for regalia, strange to say, received its strongest impetus in republican America, where, presumably, emblems of power and authority are not highly regarded. The expansion in the value of products to three and one-half times within twenty years may be regarded as evidence of growth of fraternity as shown in the multiplication of secret societies and orders and the growth of membership into millions of members.

The prosperity of the industry is also in large measure due to the rapid increase in the manufacture of all manner of raw material for silk, which is conducted in about 250 cities and towns and villages throughout the United States, extending from Massachusetts to California. The labor is largely performed by women and girls, who acquire rare skill and deftness of touch in the manipulation of the delicate raw materials used. Under the encouragement being extended by the National Government, much interest is being aroused, and the production of silk from cocoons under the care of nimble feminine fingers is now annually increasing.

Closely related to the regalia industry is the manufacture of jewelry and metallic decorations used on or in connection with regalia as emblems. This branch of the jewelry industry has become specialized and this class of work has reached a high state of artistic excellence.

Comparative Summary of the Regalia Manufacturing Industry.

	1880	1890	1900
Number of establishments...	47	137	120
Capital invested............	$452,590	$1,841,193	$1,795,858
Wage-earners................	589	2,080	1,586
Wages paid.	$174,097	$737,853	$476,580
Value of products..........	$815,638	$3,203,890	$3,077,945

Ribbons, The Making of.

Rapid Rise.—The manufacture of ribbons in the United States appears to have sprung up under the inspiration of cunningly devised mechanical appliances by which work could be so much more quickly and better done than by hand, and which rapidly excluded the hand-made goods of foreign countries.

Superior Looms.—The ribbon industry was further stimulated by the building of looms of superior design and construction, by which the finest kind of work was done at a very low cost. Under the present arrangement of the ribbon loom, the warp is placed on beams similar to broad silk looms, and each individual warp is shut off automatically from the beam, making it entirely unnecessary for the weaver to go behind the loom for this purpose. The best type of ribbon loom—the high-speed automatic—embodies all the latest improvements in construction, and is adapted to high-grade Jacquard work where high speed has been of slow adoption. It has the automatic let-off system for the warps, which is capable of a more uniform weave than the old machine and has greater productive capacity.

Perfection of Ribbon Looms.—There has recently been introduced a very efficient silk-ribbon loom, which produces the best quality of silk velvet ribbon at a very high speed, in which the pile is cut automatically in the loom. It is one of the latest triumphs of American skill in the art of weaving.

Growth of the Ribbon Industry.—The ribbon production of the United States commands the admiration of the world, not only for quality, but for merit, worth, attractiveness and low cost. Developments are being made constantly in ribbon manufacture, and it is probable that the near future will witness some very important improvements which are just now on the eve of completion. The value of ribbons produced in the United States in 1900 is given at $18,467,179; laces, nets and veils, $803,104; fringes and guimpes, $444,787.

American Skill in Ribbon Making.—The award of gold and silver medals by the management of the Paris Exposition, in 1900, to American manufacturers of plain and fancy ribbons, attests the superiority of American ribbons over those of the entire world.

Foreign Looms.—The Swiss and German power looms were used in this country up to 1899. At that time ribbon looms were introduced, in which the ease of leveling the harness, handling the warps, and the positive control of the take-up, enabled them to be run at a continuous high speed, and which drove out all other machines and suppressed European competition. It opened a broad avenue for employment to women, whereas, on the older machines, male labor was necessary.

There are 7,441 ribbon looms in the United States, of which 4,471 are adapted German looms with warps on top, 2,105 are high-speed looms, 856 are Jacquard looms and 9 hand looms.

There are 115 silk ribbon weaving mills, of which 42 are in and near Paterson, N. J., 31 in New York, 35 in Pennsylvania, and the balance scattered.

Rice Culture, Appliances for.

Early Production.—Rice in early times was extensively cultivated, and is now the chief article of diet of several hundreds of millions of the human family in India as well as in China. It constitutes half of the cereal crop of Africa. Rice contains 85 per cent. starch, but is considered less nutritious than wheat and is especially used by the peoples of warm climates where less rich food suffices.

Introduction into the Colonies.—Its cultivation in the colonies, in 1647, was attempted by the governor of Virginia, who obtained a half bushel of it from England, but no further attempt was made to establish the industry until the year 1694, when a ship from Madagascar to an American port was obliged to seek refuge in the harbor of Charleston, S. C. The captain of the vessel presented Thomas Smith, governor of the province, with a sack of the grain. This marked the practical introduction of rice culture in the United States. Up to 1860 the cultivation of rice was confined chiefly to the Carolinas and Georgia. After the Civil War the industry made a fresh start, and the prairie lands of Louisiana were brought under cultivation.

Mechanical Appliances.—The cultivation of rice was greatly stimulated by the introduction of the gang plow, the horse drill, the twine binder and of steam power. One harvesting machine operated by one man and five mules now does in one day what formerly required an entire family and hired help in a season. The development of natural oil in Texas, especially at Beaumont, which is the center of the rice belt, has stimulated rice cultivation. Rice farmers and rice millers are using this oil for fuel, and the result is seen in the wonderful increase in territory devoted to rice.

Primitive Methods.—Although rice is one of the oldest cereals and constitutes the principal food of over one-half of the people of the world, the methods of cleaning it have until recently been of very crude design. The primitive method of milling rice, and the method in vogue in China and other foreign countries, is to place a small quantity in a hollow stone or block of wood and pound it with a stone pestle. The first improvement was the use of the mortar made of a short section of a hollowed log and the pestle being a beam six to eight feet long, resting on a fulcrum. Such a mill cleans about eleven bushels per day.

Water-Power Methods.—The next advance was the water-wheel. In the process of milling rice the product is first screened, the hulls removed by rapidly revolving millstones, after which a huller separates the cuticle of the grain, from which it passes out to be polished. The finish is secured by passing the whole grains through a rapidly revolving screen with brushes or with wire gauze and sheepskin. This process gives to the rice grain its fine glossy surface, and adds to its commercial value, but detracts from its value as a food. The outer surface of the clean unpolished rice contains almost all the fats of the grain, and its removal materially lessens both the flavor and nutritive value. The fashion of highly polishing the grain popularizes it among consumers, but as a food for local consumption it is never polished.

Comparative Summary of the Rice Industry.

	1880	1890	1900
Number of establishments...	22	32	80
Capital invested	$2,166,497	$5,601,206	$2,601,352
Wage-earners	516	647	651
Wages paid.................	$110,647	$223,433	$265,585
Value of products...........	$3,133,324	$6,693,196	$8,723,726

Rock Drills, The Making of.

General Classes.—The application of machinery to rock drilling has been in use for over 150 years, but its development in its present condition of extraordinary efficiency is due to the genius and skill and study of a few mechanics of recent years. Rock-drilling machines may be grouped into two general classes—first, those that bore by percussion combined with a comparatively slow rotation of the drill, and secondly, those that drill by constant pressure and rotation, as the diamond drill. The principle of the percussion drill is that of a steam cylinder to the piston-rod of which a boring tool is attached. Rapid strokes of the piston, driven by compressed air or steam, strike the boring bit against the rock, and thus digs its way.

Requirements of a Rock Drill.—Special arrangements of parts are employed in the different rock drills. The requirements of a rock drill are that it should be simple in construction, of few parts, of light weight, of small size, but the striking parts should be relatively great and should strike the rock directly, that no other part of the piston should be exposed to violent shock; also the piston should be capable of working with a variable length of stroke, that the sudden removal of resistance should not cause injury, that the rotary motion should be automatic, and that the feed, if automatic, be regulated by the advance of the piston as the cutting advances.

Quarrying Drill.—For quarrying purposes the drill is mounted on a tripod, and it can also be used for driving tunnels underground; but one drawback is the enormous loss from condensation in the pipes, from the exhaust steam and lack of ventilation. However, long tunnels have been driven by drills operated by steam. Compressed air can be conveyed in pipes for several miles and do good work.

A Special Feature.—A special feature of the Ingersoll-Sargeant drill is that the main valve is operated by an auxiliary valve, this latter receiving its motion from the piston and acting as a trigger to the main valve. The drill strikes an uncushioned blow. Its manner of action is briefly as follows: The auxiliary valve, which is made of light steel of circular form, is so constructed as to be easily moved by the piston at the end of the stroke. It thus acts as a slide-valve to the main valve, which is moved by the air pressure, which in turn regulates the supply of air to the main piston. The main slide-valve is so held by the auxiliary that while the piston carrying the cutting tool is moved toward the rock, the full pressure of the air or steam acts upon it until the blow is struck. The full pressure is kept up until the last moment; the air is not used expansively, and as the backward stroke is an equivalent of the forward, the power of the machine to withdraw the drill from tight or crooked holes is exactly equal to its power in striking a blow. Two strong steel springs are used as buffers to avoid breakage from careless feeding. The feeding of this and all other drills used in mining or tunneling is now done by hand; but for surface work with large drills making vertical holes, an automatic feed attachment is of great value.

The Compound Principle.—The ordinary rock drill cannot, under some conditions, be worked with the same economy of steam or air as is effected in a high-class engine, and for this reason numerous devices have been introduced for controlling the admission of air to and exhaust from the cylinder. This compound principle effects a saving of nearly one-half of the air used. The rate at which a tunnel can be driven by means of rock drills may be safely taken at double the speed of hand-work. There can be no question that for driving and sinking, machine drills are far superior to hand labor in speed and economy.

Air Compressors.—Machines for compressing air are now built to be driven indirectly by water, electricity or steam. For the driving of tunnels of large sections, such as railway tunnels, special forms of carriage support are used. The drill-hole, when the machine is at work, must be kept constantly full of water. Many kinds of bits are used, each having their specific value. The single-edged bit is generally used and is very simple, and it is always preferable in hand drilling. The tapered single-edged bit does remarkable work in marble quarrying, and has drilled 350 lineal feet of 1½-inch diameter holes in one day of ten hours. In marble or limestone the edge of the bit should be sharp, and in proportion as the stone is harder, the edge should be less acute. Though sandstones are usually soft, the bits cannot be finely pointed, but should be flattened.

Value of Rock Drill.—The rock drill is one of the most valuable machines in modern civilization in ascertaining what is beneath the surface. By means of it valuable beds of minerals are found, their extent, value and limits ascertained, and thus a very thorough knowledge can be had as to the possibilities of investment and profitable returns. The mining industry relies largely on the rock drill, and the extension of its use is a pretty accurate indication of the expansion of the mining industry as a whole. The rock drill is the pioneer which opens the way for the enormous investments of capital and opens the avenue for the employment of much labor, and in this way lays the foundation for one of the greatest and most prosperous industries in America.

The old-fashioned percussion method is now rarely used for prospecting purposes, as there are simpler and more effective methods of making a hole. With the diamond drill a solid core is withdrawn of the actual rock penetrated, which gives the appearance of the strata, with their distinctive markings and with the dip and thickness of the bed.

The Diamond Drill.—The diamond drill is suitable for boring holes at any angle, up to a depth of 300 feet and 1⅜ inches diameter, bringing out a core of ⅞ inch. Hollow boring rods are revolved by the hand gearing, worked by two men, a third working a pump. The full-sized diamond drill will put down holes of 16 inches diameter to depths of more than 2,000 feet, bringing out cores up to 30 feet long, weighing more than 3 tons. The framework is of steel girders, and the power is derived from a portable engine. The cutting edge of the crown is formed of nine black diamonds, called carbonates, three on the outer edge, three on the base and three on the inside of the crown. Large holes require a greater number. The diamonds on the outer edge cut the path of the drill in its progress forward, while those on the other two faces enlarge the cavity. The rods and boring crown revolve at an average rate of 250 revolutions per minute, and cut their way through the hardest rock at the rate of 2 to 8 inches per minute. The diamonds are, as stated, black in color, and are exclusively found in the district of Bahia, Brazil. The average life of a setting, taking accidents into account, is from 6 to 8 weeks, while the speed varies from 8 feet per day in quartz or granite, to 10 feet per day of 12 hours in sandstone or slate.

The Badger Drill.—In the Phillips badger drill coiled springs on side bolts take the place of rubber buffers in the cylinder, and retain their elasticity, which is so essential, because they do not come in contact with steam or oil. This drill works with either a long or short stroke. The short stroke is good for starting holes or going through seams, and which strikes a light, quick blow. The blow in this drill is uncushioned, and the expansion of steam after its admission to the cylinder has been cut off, is used for the remainder of the stroke.

Roofers and Roofing.

A Separate Industry. — The construction of roofs has, within a few years, become practically a separate industry. The old-time conceptions of house construction involved a slanting roof, but with the expansion of construction under industrial growth, it became impractical as well as undesirable to place slanting roofs over the larger structures used for manufacturing and commercial purposes. Builders would have long ago departed from this time-honored custom of slanting roofs, but the absence of suitable roofing material for flat roofs prevented the adoption of their conceptions. It was not until within a comparatively recent period that experimenters in roofing material succeeded in manufacturing compositions which would meet all the requirements as to fire protection, economy of work and protection against rain.

Modern Buildings.—The construction of high and long buildings stimulated enterprise, and it was not long before suitable roofing compositions were produced in large quantities. Builders welcomed the innovation, and insurance companies encouraged it by reduced risks. Flat roofs, covered with roofing composition, permitted the construction of skylights and what might be regarded as light-wells, by which the lower floors were abundantly supplied with light and air. The custom of flat-roof construction, especially in buildings devoted to commercial, and to a considerable extent manufacturing purposes, became quite general.

Classification of Roofs. — Roofs are ordinarily distinguished by the material of which they are composed. The simplest kind, of course, is inclined rafters. Then we have iron roofs, wood, slate, tile and flat roofs made of well-known composition. Roofs are spoken of as gable roofs, flat, lean-to, hip, curbed, mansard, etc. The production of a strong resisting composition stimulated the introduction of flat roofs, but other influences contributed, such as the greater freedom from fire, less insurance risk and less cost of construction.

Cheap Iron and Steel.—The cheapening of iron and steel also assisted to popularize modern flat roofing, which became very generally used in large buildings. The rolling of steel into structural shapes suitable for use in heavy construction gave an impetus to steel construction, which has also been largely adopted by railroads for terminals and stations, where these modern roofing methods prevail.

Changes in Roof Construction.—The influence of architects and constructing engineers has for thirty or more years past been exerted in favor of the radical changes in roof construction which have been effected. The compositions now generally used have been tested thoroughly, and but little now remains to be done in the way of improvement. For much roofing, especially dwellings, churches and public buildings where architectural considerations have some weight, slate is largely and preferably used.

Slate.—Slate, perhaps, comes second in importance, as it constitutes a measurable protection against fire. Slates are technically known as "doubles," "ladies," "countesses," "duchesses," "princesses," "queens," "imperials," etc. A square of slate consists of 100 superficial feet. About half the slates produced in the United States are from Pennsylvania quarries, the quality of which makes it most desirable to builders and constructing engineers. The upper surface of the slate is called its "back," the under surface its "bed," the lower edge its "tail," the upper edge its "head." The part of each course of slates exposed to view is called the margin of the course, and the width of the margin is called the gauge. The portion hidden from view is called the cover. The bond or lap is the distance which the lower edge of any course overlaps the slates of the second course below, measuring from the nail-hole, and may be from two to four inches. Slates are laid on lath, battens or sheathing, and must break joint. The nails are of copper, zinc or tinned iron.

Laying on Slate.—In good slating, vertical joints of alternate courses should range in straight lines from ridge to course, and the tails should be in perfectly straight, horizontal lines. There are two methods of nailing—one near the head, the other at the center. The thickest slates should be in the lowest courses. The lowest is the doubling eaves course. Slate ridging consists of a roll and sides formed out of thick slate, and is generally somewhat twisted. Tile and pottery ridging is frequently used with slates of coarse description. In covering iron roofs, the slate may be laid on boarding or batters or upon angle iron, with the laths filled in with wood and fixed at the proper gauge. When work is to be fireproof, wood is dispensed with. Shouldering consists in embedding the slates for about a width of two inches in hair mortar mixed with ashes. It keeps the slates down tight at their tails. Slates laid on battens are frequently rendered all over the under sides with hair or lime. The boarding is frequently covered with felt, which delays the passage of air or cold and keeps the roof dry. Some slating is very wide, and is laid without boards from rafter to rafter, the lap being as usual, and the side points are covered with narrow slips bedded in putty.

An Economical Method.—A very economical system of slating with large slates is as follows: The rafters are placed at clear distances apart about 1½ inches less than the width of the slates. Down the center of each rafter is laid a fillet, thus forming a rebate on each side, in which the edges of the slate rest, secured by black putty or by a second fillet two inches wider than the first, nailed over it so as to cover the edges of the slate and hold them down. Each slate laps about 3 inches over the one below it.

Slating is sometimes laid in patterns or lozenge-wise, with angles up and down, but this method is less durable.

Rule of Pitch.—Experience shows the minimum pitch for slates of different sizes to be as follows:

LARGE SLATES.

Inclination of sides of roof to horizon.	Height of roof in parts of span.
22 degrees.	One-fifth.
26½ degrees.	One-fourth.
33 degrees.	One-third.

The more severe the climate, the smaller and lighter the slates, the steeper should be the roofs; otherwise, the wind will lift the slates and blow the rain under them.

Nature of Slate.—Slate is an argillaceous rock of various colors, blue, green, purple, gray and black, which readily splits into thin plates. It was originally formed of fine mud deposited, afterward compressed and hardened into compact rock. Beds of slate are frequently tilted at various angles and stretch across wide districts in a series of undulations, foldings, contortions, fissures, rents and dislocations. Fissures in beds of slate which follow well defined courses and form divisional planes are called joints; those beds running parallel with the "dip" are called dip-joints.

Color of Slate.—The color of slate depends mainly on the presence of iron and the form in which it exists. The common roofing slate of commerce is generally fine grained and combines great strength and durability with moderate weight. Its average weight per cubic foot is 170 pounds and it requires a weight of 20,000 pounds to crush one cubic inch.

Slate Slabs.—Slate slabs are also cut, planed, dressed and enameled, and are used for chimney pieces, billiard tables, wall linings, cisterns, paving, tombstones, ridge rolls and various other architectural and industrial purposes. Slate in which the cleavage is very close is used to make slate pencils.

For a number of reasons the use of slate as a building material is not expanding in the same proportion as most other material. Composition roofs when they are flat are preferred. Much more construction than formerly is now with flat roofs, thus barring out slate to that extent.

Comparative Summary of the Roofing Industry.

	1880	1890	1900
Number of establishments	493	2,140	2,162
Capital invested	$2,329,277	$13,303,597	$17,594,162
Wage-earners	3,082	10,937	15,362
Wages paid	$1,411,133	$6,469,514	$6,996,810
Value of products	$6,277,284	$29,412,813	$29,916,592

Rubber Tire Making.

Rubber Tires.—A rubber tire, as its name indicates, is a tire made of rubber for use on a vehicle, and is either solid or hollow or with a passage for air, which latter kind is called pneumatic.

The Original Rubber Tire.—The Dunlop tire might be regarded as the original tire, a British invention, the success of which drew the attention of all users of vehicles to its value as a means of easier riding and greater comfort. The ready acceptance of this tire led to the formation of numerous companies with large capital, which entered upon the manufacture of tires involving improvements on, or modifications of, the original Dunlop.

The Pneumatic Tire.—The extraordinary demand for pneumatic tires has stimulated invention, until at the present time there are over 1,000 patents, comparatively few of which have met with practical encouragement. The invention of the pneumatic tire was revived in the year 1889, to meet bicycle requirements, and since that time pneumatic tires have been very largely applied to vehicles, both light and heavy. Of late years pneumatic tires have been found to be unequal to the strain placed upon them, under very heavy vehicles, and resort is had to solid tires of the same material. These requirements have created an extraordinary demand for rubber, and under this demand prices have been steadily rising.

Successive Improvements.—Among the more recent patents are a self-healing tire, which is an air-cushioned tire with a lining of plastic rubber. Another improvement covers an outer shoe or cover, provided with hooked edges to engage the rim of the wheel. Still another improvement is popularly known as the "clincher" tire, in which the shoe is held to the rim by inwardly inclined flanges. A creditable tire consists of a shoe held to the rim by an adjustable clamping bend. One covers a tire with multiple air-cells, so that in case one of the cells becomes punctured, the others may be further inflated, to make up for the deficiency; and still another consists of a tire shoe or cover having non-stretching edges, which are held in the concaved rim by the inflation of the inner air tube. A recent tire covers a mandrel for forming an endless tubular sheath.

A Necessity.—Pneumatic and solid-rubber tires have thoroughly established themselves as absolutely essential accessories for the completion of pleasure vehicles. Their use, besides enhancing the comfort of the occupants of the vehicle, prolonged its life by reducing jars, shocks and strains. During the period of the popularity of the bicycle the consumption of rubber for bicycle tires assumed phenomenal proportions, and its greater use since then on vehicles, including automobiles, has more than compensated for the loss through the decline of the bicycle industry.

The Field of Rubber Tires.—The introduction of rubber into the industries has had a most important and stimulative effect in various and broadening fields. The influence of rubber in the vehicle industry is most pronounced. It is now the rule rather than the exception to use rubber tires on vehicles, and solid tires, because of their greater durability and greater freedom from destruction, are growing in favor. Tires are now made as large as seven inches in diameter, and in exceptional cases even larger. They are used on pleasure vehicles in large numbers, and are being successfully used on other vehicles, to some degree, for the hauling of merchandise.

Limits of Endurance.—Recent severe automobile racing contests, however, demonstrate that rubber tires under these ponderous machines rapidly wear out and have to be replaced with new tires after limited service. For what might be termed legitimate use in carriages and light vehicles, however, they meet all reasonable demands.

The use of rubber tires on automobiles is general and necessary; with the improving processes of manufacture and care in the selection of rubber as to quality, the rubber tire is being found capable of sustaining severe and continuous traffic on vehicles of considerable weight.

Consumption.—The consumption of rubber in the tire industry is steadily growing, and the demand in general is leading to the establishment of rubber plantations in various parts of the world, besides leading to the further opening up on a scale of great magnitude the rubber-producing territory of Brazil.

Comparative Summary of the Rubber and Elastic Goods Industry.

	1880	1890	1900
Number of establishments ..	90	139	262
Capital invested............	$6,057,987	$13,703,787	$39,304,853
Wage-earners..............	6,268	9,183	20,405
Wages paid................	$2,295,972	$3,663,976	$8,082,938
Value of products	$13,751,724	$18,708,917	$52,627,030

These figures, of course, cover the entire rubber industry, including all the multifarious products into which rubber enters; but they serve to indicate the enormous and remarkably rapid growth in the many special branches during the past two decades. As will be seen, the value of products has increased fourfold within twenty years.

The supply has not kept pace with the extraordinary demand in recent years and hence prices have materially advanced.

Safes and Vaults, The Making of.

The Safe.—The safe is a comparatively modern device to guard valuables against loss by fire or attacks of thieves. The exigencies and requirements of modern society call for the creation of a vast amount of paper evidences of value, such as deeds, banknotes and securities of all descriptions, including books containing records of especial commercial or legal value. From a simple iron, portable box with its simple lock, the safe has progressed through a long series of improvements in order to more securely preserve its contents against fire and breaking.

Construction.—In ordinary safe manufacture the outer casting is made of boiler plate, backed by a lining of hard steel, over which is an inner lining of thin boiler plate, the three layers being securely bolted together by screws from within. By some makers a layer of hard metal is poured in a fluid state between the outer and inner casing. Others case-harden the surface. Various manufacturers adopt numerous devices for securing the required combinations of hardness and toughness. To prevent wrenching of joints, the two sides, with top and bottom of the outer shell, are sometimes made out of a single plate, welded at the joint, and the back and front are then attached to that shell by angle irons screwed from within.

Special Precautions.—The frame upon which the door hangs, and into which the bolts shoot, is made of great strength, with special precautions to prevent the wrenching off of the door. In an ordinary safe the fixed dogs or sham bolts fit into slots at the back or hinged sides. In all good safes bolts shoot on every side, front, back, top and bottom. In order to defy wrenching, additional grip is secured in some safes by a bolt with a clutch or projection, which falls into a recess in the slot and thus holds against any direct wrench.

Early Patents.—Among the earlier patents was one by Charles Chubb, in 1835, which provided a series of ponderous bolts, secured in a locked position by a small key. Keyless locks and time-locks have been generally adopted. In keyless permutation locks, such as those of Hall, Sargent, Yale and Dalton, the bolts can be withdrawn only after an indicator has been successfully set against a combination of numbers arranged before closing the door. In the time-lock of these inventors, the safe can only be opened at a set time. Electrical devices are also arranged to carry signals.

Mixtures Used.—Among the mixtures used as a lining for fire-resisting material are sawdust and powdered gypsum or cement or infusorial earth, with ground alum, asbestos, silicate cotton, mica and sealed tubes of alkaline salts. A carefully jacked shell of sufficiently thick fire-resisting material should line every fire-proof safe. The necessities of business frequently require that entire rooms be transformed into safe-resisting power.

Patents Taken Out.—Up to 1890, 613 patents for safes had been issued, the later improvements being designed to prevent lockouts and in introducing devices that can be opened by heavy machinery at either end of a railroad route. Safes are made of parts telescoped or crowded together by hydraulic power, requiring heavy machinery for locking and unlocking. Safes are also made to prevent the use of liquid explosives, such as nitroglycerine, around the door openings. One invention prevents the use of the electric arc in melting or fusing a hole through the safe wall or door. Dogging devices are used which control the bolt works of safes.

Dimensions and Vault Equipment.—The dimensions of one of the largest safes in the world, in a Pittsburg (Pa.) bank, are: Length, 43 feet 11 inches; width, 23 feet 6 inches; height, 8 feet; weight, 446 tons, or 892,000 pounds; number of plates of steel, 22; size of front plates, 9 feet 6 inches by 9 feet 1¾ inches; side plates, 9 feet 3 inches by 15 feet and ½ inch; top plates, 24 feet by 9 feet 1¾ inches; thickness of front, bottom, side and top plates, 6 inches. The doors of this vault are marvels of their kind. Most vaults have but one large door, with a small one to be used in case of an accident occurring which locked the large door shut. The vault is equipped with two very large doors of the same size, one at each end. Each is guarded by four time-locks. Each door weighs 17 tons, or 34,000 pounds, and each is hung on a single hinge so truly that with one hand the door can be swung to and fro.

United States Mint Vaults.—The vaults of the United States Mint at Philadelphia are three in number—one for silver dollars, 11 feet high, 53 feet wide and 100 feet deep; the silver bullion vault, 11 feet high, 53 feet wide and 80 feet deep; a gold and subsidiary vault, 11 feet high, 22 feet deep and 120 feet long. These vaults are constructed of drill-proof steel; the doors and flanges are constructed on an air-cushion system which precludes the possibility of chemical explosives being used.

Locks.—One type of locks used in deposit vaults is designed for a primary key in the keeping of the janitor, and a secondary key held by the box-holder. Locking systems have been largely introduced, which comprise a series of locks for locking doors, windows, water faucets, switches. A series lock adapted for hotels, one for each room, and which may also be simultaneously operated from a central point, is in quite general use.

Comparative Statement of the Safe and Vault Industry.

	1880	1890	1900
Number of establishments...	40	39	35
Capital invested	$2,201,600	$4,603,118	$5,479,879
Wage earners	2,206	3,816	2,033
Wages paid..................	$1,096,504	$2,129,615	$1,017,237
Value of products	$3,352,396	$6,641,844	$3,927,867

Salt Making.

Salt Supply.—Just how the ancients obtained their supplies of salt is not known. That salt was mined, manufactured and used in most ancient times is confirmed by history. The salt bed of Northwich, in Cheshire, England, has been known since Roman times and been worked since 1670. Vast beds of salt exist in the United States, one of the chief deposits of rock salt being on the Petit Anse Island, La. The salt in these beds is practically inexhaustible in quantity and remarkably pure in quality. In different localities in New York and Michigan salt is pumped up as brine and recovered by evaporation. Salt is not only used for seasoning and for the preservation of food, but to glaze pottery, harden soap, etc.

Early Salt Making.—Salt was made from brine other than sea water in the latter years of the eighteenth century. Salt works were erected on Big Beaver Creek, in Western Pennsylvania, in 1774, and later in many localities throughout the West. It was a very scarce article in the early history of the colonies, and was imported at high cost for a long time. It was not until a comparatively recent period that its production assumed commercial importance.

How Obtained.—At the present time nearly all the evaporated salt is obtained by sinking wells to the salt body, pumping fresh water into the wells and withdrawing the brine after it is well saturated. Salt is produced in many States of the Union, the output increasing continuously since 1850. During the past twenty years the industry developed threefold. A great many of the smaller plants which have been struggling along were driven out of business by the consolidation of a number of large establishments between New York and Kansas, Utah and California.

Methods of Making.—Salt manufactured by artificial heat is made in kettles, open pans, vacuum pans and grainers, the heat being applied directly or by steam. In grainers and vacuum pans steam heat is used. This process is essentially American. The brine is evaporated from rectangular vats about 12 inches deep, in which are suspended coils of pipe carrying either live or exhaust steam. In some cases the salt is removed from the bottom of the pan by mechanical scrapers.

Solar and Rock Salt.—Solar salt is made in vats or ponds; rock salt is mined in New York, Kansas, Louisiana and California. Practically all the product of salt water by solar evaporation is made along the shores of San Francisco Bay, in California, and the Great Salt Lake, Utah. Michigan is a very important salt-producing State, and the industry is developing steadily. The production of rock salt in New York varies from 150,000 to 250,000 tons annually. The industry in other States is being industriously prosecuted, though it occupies a minor position in the great family of industries.

Rock Salt.—Rock salt is first under-cut with mining or channeling machines operated by compressed air. Holes are made in the salt with air drills and dynamite, exploded by electricity, which brings the salt rock down to the floor of the mine. It is then loaded on cars, conveyed to the shaft by railroads and hoisted to the surface, and there dumped automatically from mine cars into crushers over dumps, and passes by gravity through different sized crushers to the screen-room below, where it is screened into various sizes, from whence it is conveyed to large bins, where it is loaded into cars. The largest body of rock salt was discovered at Lyons, Kans., in 1887. Here are fifteen workable veins of rock salt, ranging from 4 to 18 feet in thickness.

In Utah, where salt is made by solar evaporation, the pumps are started each year about the month of March, the brine being pumped into large reservoirs, each covering from 10 to 20 acres. As the brine becomes stronger, it is drawn off into other reservoirs or sloughs, covering from 3 to 15 acres. Sloughs are made with a hard clay bottom and with a levee thrown up three or four feet high around the sides to retain the brine and at the same time furnish a ditch on the outside to carry off fresh water. The sloughs are replenished from time to time during the summer. The reservoirs are kept stocked until September or October, by which time salt is deposited to the depth of from 3 to 6 inches. Harvesting then begins, and the salt is stacked on the banks in large piles. It is then hauled to the mines for refining, or is shipped to silver mills working under the chlorination process. The latest improved machinery consists of revolving cylinders, burr rollers and a series of sieves. The salt is hauled to a crusher, whence it is carried by hoppers to the heated cylinders, which deliver it perfectly dried to the roller burrs, from whence it goes to the sieves. It is purified by means of a suction blower as it passes over them. The impurities are lighter than the salt, which passes on to the bins.

The salt produced is classified as follows: Table and dairy salt, common fine, common coarse, packers', coarse solar, rock salt, milling salt.

The processes employed require the use of covers or ponds, grainers, open pans, kettles and vacuum pans.

The production of salt increased from 1,952,268 barrels in 1850 to 5,961,060 barrels in 1880, 10,806,860 barrels in 1890, and to 15,187,819 barrels in 1900, three-fourths of which was made by the boiling process.

Comparative Summary of the Salt Industry.

	1880	1890	1900
Number of establishments..	276	200	159
Capital invested............	$8,548,640	$13.437,749	$27,123,364
Wage-earners................	4,493	4,255	4,774
Wages paid..................	$1,305,020	$1,593,442	$1,911,140
Value of products...........	$5,191,222	$5,484,618	$7,966,897

Sand and Emery Paper and Emery Wheels.

Composition of Emery.—A general definition of emery may be given as an impure variety of corundum mixed chiefly with the magnetic oxyd of iron. It is always associated with diaspore, emerylite, chlorite and titaniferous iron. Prior to its discovery in Chester, Mass., in 1863, and subsequently elsewhere, emery was largely imported, much of it coming from the Island of Navos in the Grecian Archipelago.

Uses of Emery.—Emery is a variety of corundum, granular in texture and black or grayish-black in color. It is found in various parts of the United States and when powdered is largely used for polishing hard substances.

The Emery Wheel.—The emery wheel, in which emery is imbedded by pressure, or more commonly a wooden wheel covered with leather and with a surface of emery, is largely used for polishing purposes, especially where an extremely fine edge or surface is desired. The wheel is usually fastened to a mandrel and rotated by a wheel and band, and it is principally used in grinding and polishing metallic surfaces, especially cutlery. It is sometimes called a corundum wheel from the name of the crystalline alumina used on it. The susceptibility of emery to almost infinite indivisibility makes it a most valuable material for polishing.

Best Emery Wheels.—The best emery wheels are formed of clean, pure emery compounded with a certain amount of boiled linseed oil. In the preparation of it the mixture is agitated for a sufficient period under proper temperature with a free access of atmospheric air or some powerful oxidizing agent. Under this treatment it assumes proper tenacity and while warm is subjected to hydraulic pressure in a suitable mold, and being subsequently dried, is ready for use. Emery wheels can also be made with shellac powdered fine and a fine portion of rosin and some other compositions.

Sandpaper.—The manufacture of sandpaper is apparently a simple process, but it requires specially adapted machinery and various appliances, involving in their application considerable skill whereby the proper proportion of sand of a proper fineness is equally applied to the entire surface.

The manufacture of emery paper is analogous to that of sandpaper but requires special appliances, greater care and skill. The familiar uses of emery paper are multiplying in the mechanical industries and the arts and some of the more recent products of pulverized emery are used for polishing of surfaces with microscopic minuteness.

Emery Statistics.—The number of establishments making wheels increased during the past twenty years from 11 to 34; number of wage earners, from 112 to 546; capital invested, from $397,000 to $1,489,527, and value of products from $322,022 to $1,381,675.

Sandpaper Statistics.—The number of establishments engaged in the manufacture of sandpaper and emery paper increased during that period from 6 to 9; workmen, from 82 to 284; capital invested, from $121,500 to $1.732,307, and value of products from $262,374 to $1,175,895.

The industrial uses of sandpaper have increased its demand fivefold during the past twenty years.

Saws—Manufacture and Uses.

Saws Among the Ancients.—The Greeks claim the invention of the saw, but it is evident from Egyptian monuments and from remains that have come down to us from the bronze age, that saws were in use long before the Greeks used them. Saws of the bronze age have been found in Germany and Denmark, and in the stone age, saws of flint were fixed to wooden handles. Saws were also made of sharks' teeth and notched shells.

Kinds of Saws.—Saws are used to cut wood, stone, ivory and many other materials, and are either reciprocating or circular and of various sizes and forms. They may be divided into hand-saws and machine-saws, and under the former those most commonly used are the band-saw, the cross-cut saw, the frame-saw, the hand-saw, the panel-saw, the keyhole-saw, the bow-saw, ripping-saw, sash-saw, tenon-saw and others.

Machine Saws.—Machine saws are divided into circular, reciprocating and band. The circular saw is a disk of steel with teeth on its circumference, which cuts the material as it is pushed to it. The reciprocating saw is fixed, and works like a two-handled saw. The ribbon-saw is a thin, endless saw, placed over two wheels and strained on them, and which passes down through a flat sawing-table.

Why Saws Sometimes Make Trouble.—Some of the reasons why saws do not give satisfaction may be enumerated as follows: Insufficient power to maintain regular speed; too thin for the work; too many or not enough teeth for the amount of feed carried; weak or imperfect collars, which may not be large enough in diameter; ill-fitting mandrels and pinholes; uneven setting and filing; not enough set for proper clearance; too much pitch or hook of teeth; irregular and shallow gullets; out of round, and consequently out of balance; a sprung mandrel or lost motion in mandrel boxes; a carriage track neither level nor straight; carriage not properly aligned with saw; lost motion in carriage trucks; heating of journal next to saw; guide-pins too tight or not properly adjusted; backs of teeth too high for clearance, and too long running without sharpening.

Essential Conditions. — A saw-tooth becomes dull on the side, or under the point, in proportion to the amount of feed. It is very important that the foundation of the mill withstand shocks, and that the saw-frame be firmly secured, level and solid.

Tension of Saws.—Large saws should have a perfect bearing of three-quarters of an inch on the outer rim, the other part clear. The tension of saws must be adjusted to overcome slight variations in speed, regularity being a prime consideration.

Speed of Saws.—The speed of a 72-inch saw, running 10,000 feet per minute on the rim, makes 530 revolutions per minute; a 48-inch saw, 815 revolutions per minute; a 36-inch saw, 1,080 revolutions per minute; a 24-inch saw, 1,960 revolutions per minute; a 12-inch saw, 3,260 revolutions per minute; an 8-inch saw, 4,600 revolutions per minute.

Rules for Calculating Speed.—Rules for calculating speed are as follows:

1. Knowing the diameter of the driving and driven pulleys and the speed of the driver, the speed of the driven is found by multiplying the diameter of the driver by its number of revolutions, and dividing the product by the diameter of the driven. The quotient will be the number of revolutions of the driven.

2. To find the diameter of the driver, the diameter and revolutions of the driven pulley being given, multiply the revolutions of the driven by its diameter and divide the product by the revolutions of the driving-shaft. The quotient will be the diameter of the driver.

Directions for Using Saws.—A few common-sense directions for the keeping and fitting of saws may be briefly summarized as follows:

Take up all the end-play or lateral motion in the mandrel; see that the carriage track is level, straight, solid and in proper line; see that the rolls or trucks have no end-play; keep all gum or sawdust off the tracks; keep the saws sharp, ground and swaged enough for clearance; do all the filing on the under or front side of tooth, filing square across the teeth. Never file square corners in the gullets of saws of any kind, as this renders them liable to break. When there is occasion to swage or upset the teeth of the saw, file them off to a sharp point; it saves time and saves the saw, for the sharper the teeth, the more easily will they upset or swage. Keep the teeth in as good shape as when new, for if they lose any of the hook or rake or sawdust chamber, the saw will use more power and be harder to keep in order, and will make inferior lumber. Keep the saw well balanced and the gullets well gummed out.

Thin Saws.—A thin saw requires just as much clearance as any other saw, hence in proportion to thickness a thin saw has the most strain to bear.

Thin saws require more teeth than heavier ones to do the same class of sawing. In extra thin saws one-sixth more speed than is given in the usual tables will be an advantage.

How to Handle Gritty Logs.—In sawing sandy or gritty logs the edges of the inner circles of the holders are liable to wear and become rounded, which tends to create friction. This can be prevented by filing the edges of the inner circles of the holders across and kept square.

Additional Directions.—The points should be sharpened or filed without taking them out of the saw. The filing should be done on the front or throat tooth of the saw. Care should be taken to keep the cutting edge at right angles to the side of the saw. Do not use a square-cornered file.

The Cutting Edges.—A very important point to be kept in sight is to keep the cutting edges of the points widest. If the points are filed so that they are wider behind the cutting edges than on the extreme corners, good work cannot be done.

Changing Teeth.—In changing teeth, first drive them into position by placing a swage on the cutting edge and striking a blow with a light hammer, being careful to not expand the rim of the saw by riveting too tightly.

Adjusting Tension.—The hammering and adjusting of the tension of circular saws requires care and knowledge. For this purpose an anvil is necessary, one round-face and one cross-face hammer, two straight edges—one from 14 to 18 inches long and one about 48 inches long—and one tri-mandrel.

Testing for Tension.—In testing for the tension, be sure to have the straight edge at right angles with the part of the saw resting on the board and the opposite edge, which is being raised with the left hand while the straight edge is held, and then gently pressed down with the right hand. Do not lean the straight edge to one side, but hold it up straight, or it will fall to the form of the saw, and not show what the mechanic wants to see.

Variety of Saws.—Saws are made for every conceivable purpose. Among them may be mentioned the inserted-tooth saw, chisel-point circular saw, rift-saws, shingle-saws, concave-saws, barrel-stave saws, grooving-saws, milling-saws for cutting metal, mitre-saws, bilge-saws, ice-saws, cross-cut saws and many others, including disks for cutting hot or cold iron.

Cutting Cold Steel or Iron.—For fast cutting of cold steel or iron, friction disks are used. For hot steel and iron, saws having teeth varying from three-eighths to seven-eighths of an inch in space are used. These saws and disks are run at a high and uniform speed. Hot saws should be run at the rate of about 20,000 feet per minute; disks for cutting cold iron and steel, 24,000 feet per minute. The mandrel and collars must be heavy, large and true. Hot saws should be kept sharp or they will jam or break. For slow-motion or milling-saws for cutting steel rails, beams, etc., the saw should run 45 feet per minute, with a feed of three-quarters of an inch per minute.

The Band-Saw.—The life of a band-saw depends very largely on the way it is handled. Until a new saw gets its proper aligning or "tilt," it cannot give as good result as an older saw. There is a certain quality about a new band-saw which is sometimes termed "surplus elasticity," and until this is brought down to its proper bearing by the judicious use of the hammer and saw-stretcher in connection with the first "runs" of the saw, it will not be at its best.

Cracking of Saws.—All experienced filers and mill men know that excessive speed, too much tension, uneven tension, case-hardening or glazing from the emery-wheel, gum adhering to the face of the wheels, crystallization from too heavy hammering, cuts on the surface of the saw from sharp-faced hammers, vibration of either machine or saw, sharp angles in the gullets, imperfectly adjusted guides, backs of saws too long or too short and excessively cross-aligned to make them crack, insufficient throat-room and hook, crowding the saw against the guard-wheel, are liable to cause the saw to crack.

Belting for Saws.—Belt motion should not exceed 3,000 feet per minute; where narrow belts are run over small pulleys, a distance of 15 feet between shafts is right, and which gives a sag of $1\frac{1}{2}$ to 2 inches in the belt. For main belts working on large pulleys a greater distance and sag are desirable. The strongest side of the belt is the flesh side, one-third way through. A common rule for determining the width of a single belt, three-sixteenths of an inch thick, to transmit any number of horse-power, is to multiply the actual horse-power by 1,000, and divide by the velocity of the belt in feet per minute, which gives the width in inches. A belt one inch wide and 800 feet per minute, is equal to one horse-power.

Rule.—To find the length of a belt, add the diameter of the two pulleys together, divide the result by 2, and multiply the quotient by $3\frac{1}{7}$, then add the product of twice the distance between the centers of shafts, and you have the length required.

The resistance of belts to slipping is independent of their breadth. There is no advantage derived in increasing the width beyond that necessary to resist the strain to which it is subjected. Long belts are more effective than short ones. The strain of 350 pounds per square inch of section is a safe working load. The pulley should be a little wider than the belt.

The average thickness of single belts is three-sixteenths of an inch, and a safe working load is assumed to be 45 pounds per inch in width, which, at a velocity of 60 square feet per minute, is equal to one horse-power.

Comparative Summary of the Saw Making Industry.

	1880	1890	1900
Number of establishments..	89	95	96
Capital invested	$3,281,135	$6,313,373	$8,508,487
Wage-earners.................	2,566	2,676	3,215
Wages paid..................	$1,226,370	$1,583,526	$1,692,757
Value of products...........	$3,943,105	$5,572,992	$6,443,748

Scale and Balance Making.

Scales.—The art of scale making has been improved to a remarkable degree in the direction of delicate scales since the development of chemistry and its daughter, the pharmaceutical industry.

Unchanged Construction.—There are no very particular features in the scales for weighing heavy commercial products. In the development of commercial activities, which necessitates rapid handling and frequent exchanges, the art of building heavy scales has been developed to a high degree of perfection. The principle embodied is based upon fundamental conditions, and in their construction they embody practically nothing more than extension of the primary laws of the lever.

The Difficulty of Friction.—There are 1,209 patents on record for scales manufacture, and yet inventors are as hard at work as though the world were without means of weighing its merchandise. A great effort has been made to produce a spring-weighing scale which will accurately and automatically not only show the weight but the total price of the goods weighed, the price per unit of weight being known. The practical difficulty to be overcome is inaccuracy of the machine caused by friction between its movable parts.

Weighing and Registering.—Another class of weighing machines coming into general use, weigh automatically and accurately, and register the weight of large masses of material, such as grain, coal, cotton seed and the like.

Self-Adjusting Poise.—This style of machine is marked by a construction in which more than enough material is supplied to the weighing receptacle to bring the weigh beam to a poising position, the excess being discharged from the receptacle automatically until a poise is effected. The type of weighing machine in which the grain is first measured or weighed in gross so as to get a load approximating that necessary to balance the scales before the precise weighing operation proper has begun, has been so improved as to be brought into general favor.

Other improvements consist in devices for automatically compensating for variations in temperature in the indication of a spring balance.

Measurers of Values.—Remarkable progress has been made in every line of scale manufacture, from the mammoth scales which weigh carloads with practical accuracy to the delicate scales of the chemist, druggist and electrician. The major portion of the enormous production of our vast industries passes over the scales and balances in one way or another, in order to determine the values exchanged. Scales are the court of last resort in a large portion of the industrial domain, and by their aid, is made an infinitude of adjustments in daily business life which determine the measure of value received between buyers and sellers. Their value in the manufacturing industries has been vastly increased since the introduction of scientific methods of manufacture, when so many operations are conducted and determined by quantities of materials used. The passage from crude methods of production to refined has been marked as well as facilitated by the use of scales for major and minor necessities.

The use of scales in the weighing of materials in nearly all branches of industry has very greatly subserved economy of material, saved time and has made possible the conduct of many industrial operations on a scale of vast magnitude.

Comparative Summary of the Manufacture of Scales and Balances.

	1880	1890	1900
Number of establishments..	64	76	86
Capital invested	$3,814,981	$1,658,655	$6,307,576
Wage-earners	1,554	1,350	2,775
Wages paid..................	$783,019	$692,497	$1,436,839
Value of products..........	$3,250,460	$2,322,744	$5,239,788

Scientific Instruments.

Field for Scientific Instruments.—Scarcely an industry could be named in which scientific instruments are not used. It is the distinguishing characteristic of modern civilization that scientific methods are followed. The objective point in all methods of production is to find the basis upon which matter rests, and then provide those methods in its manipulation which are required by the laws which underlie its existence and action. It would require a volume to merely enumerate the scientific instruments now used in all lines of activity. The scientific instrument is the daughter of the mechanical tool. In the domain of mechanics there are a vast number of instruments used to ascertain condition, quality, strength, value, use and economy. In the chemical industry there are hundreds of instruments in use by which the nature, action and activities of the elements are ascertained. In electricity there are numerous instruments, mainly for measurement purposes, but also to detect and reveal conditions beyond the range of vision or sense.

Uses.—Instruments come to aid the hand in performing innumerable delicate operations which the hand itself is unable to even attempt. The range of their work is limitless, and by their aid the efficiency of labor is increased and a volume of results and achievements made possible without which much that is now done would remain undone.

In the physical sciences, in electrical and engineering work, in astronomy and chemistry, in all manner of research work, in optics and acoustics and in surgery — in short, in every channel of physical effort where work is to be done—an instrument is devised and used to facilitate that work and increase the volume of results.

Functions of Instruments. — Scientific instruments see, feel, hear, count, analyze and determine. They are the mechanical five senses of man, and stand midway between thought and action, between conception and execution. Some start where the senses reach their limit, and penetrate into conditions and secrets which human senses cannot penetrate. Much of the knowledge of the world is the gift and the work of instruments.

Never before was as much reliance placed on instruments as to-day, and never had they as great a mapped-out work to do. The instrument sees into the depths of outer space, and determines the composition of the most remote bodies of the universe. They peer into the most microscopic forms of organic and inorganic matter, and open up to the senses their secrets. They lend their hand in each and every industry. They pioneer the way for progress. They gather up the discoveries of science and scientific study, as well as the results of industrial discernments, and enable us to label them according to their nature and importance.

The growth of the scientific instrument industry has been rapid. It keeps pace with civilization and is the handmaid of education. It proffers to the student and scholar and investigator and inventor better means for the prosecution of work. It accepts no limitations on its usefulness, and acknowledges no boundaries for its future growth.

Comparative Summary of the Scientific Instrument Industry

	1880	1890	1900
Number of establishments...	171	233	265
Capital invested............	$1,342,196	2,936 021	$4,491,627
Wage-earners	1,099	1.978	2,786
Wages paid	$588,751	$1,191.588	$1,433,715
Value of products...........	$1,639,094	$3,271,616	$4,896,631

Sewing Machines and Makers.

Origin.—The foundation of machine sewing was laid by the invention of a double-pointed needle with the eye in the center, patented by Charles F. Weiser in 1755. This device was intended to obviate the necessity of inverting the needle in sewing or embroidery, and it was subsequently utilized in Heilman's embroidery machine. Thomas Saint secured a patent in 1790 for a machine for stitching, quilting or sewing, which was used principally on leather work. It had an awl which, working vertically, pierced a hole for the thread. Had Saint hit upon the idea of an eye-pointed needle, he would have anticipated the modern chain-stitch machine.

Improvements.—Berthelemy Thimonier, a poor French tailor, patented an apparatus in 1830, in which the needle crocheted, and, descending through the cloth, brought up a loop of thread, which it carried through the previously made loop, and thus formed a chain on the upper surface of the fabric. The inventor did not secure its adoption. He produced a set of machines which made 200 stitches a minute, and which sewed and embroidered any material from muslin to leather. His machines were destroyed by a mob, and he barely escaped with his life.

The Eye at the Point of the Needle.—Walter Hunt, of New York, about the years 1832-34, first conceived the idea of the eye in the end of the needle and a double-thread or lock stitch. He constructed a machine with a vibrating arm, with a curved needle at its extremity, and with an eye near its point. By this needle a loop of thread was formed under the cloth to be sewed, and through that loop a thread, carried in an oscillating shuttle, was passed, thus making the lock stitch of all ordinary two-thread machines. No attempt was made to patent it until 1853, when the claim was disallowed on the ground of abandonment.

Elias Howe.—Working unconsciously along the same lines, Elias Howe, of Spencer, Mass., in 1844, completed a rough model of a sewing machine, which in 1846 was patented; this was the first patent for a lock-stitch machine. There were two essential features in it—the curved eye-pointed needle and the under-thread shuttle—which, it is said, were invented by Walter Hunt twelve years before. Howe sold the English right and went to England to further improve the machine, but returned to America in 1849. Meanwhile, various inventors had improved the original "Howe," some of which were demonstrated to be invasions.

Singer and Other Inventors.—In 1851 Isaac Merritt Singer secured a patent for a sewing machine, and entered upon its construction and sale with great energy. Serious and prolonged litigation ensued between Howe and the later inventors, and ultimately all makers became tributary to Howe. The extraordinary value of the sewing machine was soon demonstrated, and an immense demand sprang up for it, which still further stimulated latent invention. One of the most ingenious of the many patents brought out was that of Allan B. Wilson, who in 1849 devised the rotary hook and bobbin combination, which later on formed the special feature of the Wheeler & Wilson machine. The effective four-motion feed was invented in 1850. In the following year William O. Grover, a Boston tailor, patented the double-chain action, which formed the basis of the Grover & Baker machine. In 1856 A. E. Gibbs, a Virginia farmer, devised the improved chain-stitch machine, later known as the Wilcox & Gibbs machine. Several thousand patents have been issued for sewing machines, and even now inventive talent refuses to be comforted. In all these the main principles of the various machines have not been affected.

Three Variations of Stitch. — There are three varieties of stitch—simple chain or tambour stitch, double chain, and lock stitch. The lock stitch is peculiar to machine sewing. By proper tension the threads interlock within the work and the stitch shows the same on both sides. To make the chain stitch, the under thread has to be passed through the loop of the upper thread, which is done in two ways, one being introduced by Hunt and Howe and improved by Singer and others. The other method seizes the loop of the upper thread, and a rotating hook expands the loop and passes it around a stationary bobbin within which is wound the under thread, known as the Wheeler & Wilcox principle.

Features of Machines.—Wilson's "four-motion feed," invented in 1850, consisted of a serrated plate which rises through a groove in the table. The cloth is pushed forward while the needle is above the surface. This lock stitch was made by a rotating hook for interlocking the upper thread with the lower.

A Special Feature.—Singer's machine had a rigid overhanging arm which guided the vertical needle in combination with a shuttle and a wheel feed. The shuttle was driven in its race below the feed table by a mechanism deriving its motion from the shaft by means of gearing. The feed carried the cloth forward between the stitches without injury to the fabric, and the cloth, which could be turned in any direction, was held in place by a presser foot which had a yielding spring which would permit of passing over seams and automatically adjusting itself to any thickness of cloth. He produced a machine which used the single-chain stitch and also the double-chain stitch, for ornamental work and embroidery. The general style of the original Singer has been universally copied.

Machines for Boot and Shoe Making.—Machines have been perfected for stitching with waxed thread, for use in the manufacture of boots and shoes, saddlery and harness, and other articles of leather.

Power Machines.—Heavy power machines are used in the manufacture of awnings, tents, sails, canvas belts, etc. There are specially constructed machines for stitching gloves, others for sewing the seams in carpets, sewing the ends of filled bags, stitching brooms, embroidering, machines for working button-holes and sewing on buttons.

This has resulted in the building up of industries for the manufacture of various interchangeable parts of machines. Besides all these, there are machines for crimping the cloth into ridges for passage over the needle, short-thread sewing

Sewing Machine Industry.

... SEWING MACHINES ...

No. of Establishments 58

Wage Earners. 10,635

Wages Paid $6,213,938.

Value of Product $18,314,419

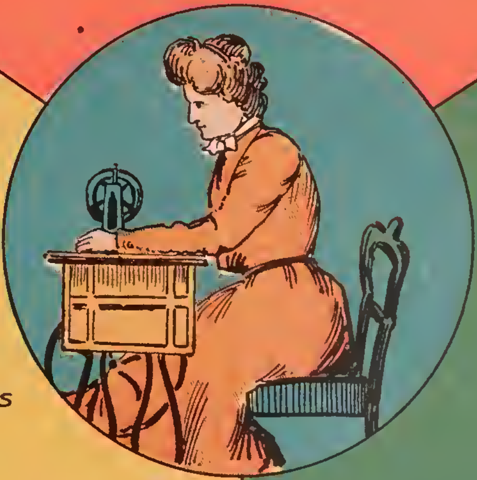
SEWING MACHINE REPAIRING.

No of Establishments 396

Wage Earners 310

Wages Paid $154,036

Value of Products $710,123



SEWING MACHINE CASES.

No. of Establishments 7.

Wage Earners 2,653

Wages Paid. $1,065,180

Value of Product. $2,815,142.

Pen and Pencil Industry

STEEL PENS.

No of Establishments 3

Wage Earners 473

Wages Paid $138,433

Value of Product. $294,340

GOLD PENS.

No. of Establishments 22.

Wage Earners 378

Wages Paid $229,679

Value of Product. $799,078.

FOUNTAIN PENS

No of Establishments. 23.

Wage Earners. 318

Wages Paid $141,012

Value of Product. $906,454.

LEAD PENCILS

No. of Establishments 7

Wage Earners 2,162

Wages Paid $638,281

Value of Product. $2,222,276.

engines, running-stitch machines, reciprocating lock-stitch machines, chain-stitch machines, chain-stitch machines for two or more threads, binder machines for binding hats, hemmers for sewing umbrellas, chain-stitch two-thread machines with embroidery attachment for carrying a third thread, lock-stitch machines with two needles for over-seaming and felling lap seams.

Power for Operating.—Means have been perfected for operating sewing machines with water motors, air engines, steam engines and springs and weights, and by electricity. Electric sewing machines are now produced which are practical. Steam-power machines are also used in large factories where the power is applied by means of shafting under long rows of tables bearing the machines, one row of shafting operating two rows of machines. Sewing machines have resulted in the concentration of the clothing and the boot and shoe industries.

Influence.—A résumé of the industry as it exists to-day would involve a mass of facts and figures which, while valuable as evidence of enormous and rapid growth in several States of the Union, would be lacking in special features of interest to the average reader, who already knows of its extent. It would be a more appropriate theme for the schoolgirl graduate to elaborate upon the influences which the sewing machine has had on society, and particularly on the household, than the encyclopedia writer. That it has a very stimulating influence indirectly on the textile industry is evident. It has vastly stimulated the production of feminine apparel especially, and has led to the development of specialized skill and taste, and in no small degree it is to be credited with the exquisite taste in dress manifested and so exceptionally maintained by American women.

Comparative Summary of the Sewing Machine Making Industry in the United States for Three Decades.

	1880	1890	1900
Number of establishments...	106	59	58
Capital invested.............	$12,501,830	$16,043,136	$18,739,459
Wage-earners................	9,553	8,837	10,635
Wages paid..................	$4,636,699	$4,750,324	$6,213 938
Value of products............	$13,863,188	$12,823,147	$18,314,419

Shipbuilding and Builders.

Early Ships.—The earliest "ship" of which we have historic cognizance was built 3,000 years before Christ. It has been within fifty years, however, that practically all the progress has been made along scientific lines since the departure from early conceptions. Shipbuilding for centuries involved only such requirements in construction as enabled navigators to sail along or near the European coast or across limited bodies of water. With the gradual settlement of America the necessity was recognized for larger and more substantial ships, and this requirement was fairly met by the construction of ships of considerable size. With the introduction of steam and machinery, new possibilities arose, but the shipbuilders for a long time hugged their conceptions and restricted their efforts to sailing vessels and vessels of modest dimensions.

The First Steamer.—At last venturesome experiments were made with vessels of considerable size and very creditable equipment, but it was not until 1837 that the first steamer was built for regular voyages between England and the United States. The first vessel to cope with this inviting problem was the "Great Western," built at Bristol, England, 212 feet long, and propelled by paddles. Iron had been largely used previously for vessels for rivers, canals and coast service. The largest "iron" vessel in 1841 was 200 feet long. In 1843 the first iron ocean-going vessel was built, which was propelled by a screw and was named the "Great Britain," 286 feet long.

The "Great Eastern."—In 1850 Brunel entered on the construction of very large vessels for the sake of economy in power. A leap in designing was taken when it was decided, after long deliberation by Brunel and Russel, to build a vessel 680 feet long, 83 feet beam, with a screw engine and indicated horse-power of 4,000. This was named the "Great Eastern."

The essential features of ship construction which then began to engage the close attention of the naval engineers, designers and shipbuilders were power, speed, capacity and safety. On this side of the Atlantic, shipbuilding had prospered from the beginning of the nineteenth century, and the American flag was no stranger on the Atlantic Ocean and throughout the world, but the vessels were constructed without regard to greater speed than wind and sails afforded. American enterprise led the way and disputed the control of the seas with all other countries, and maintained its hold until the breaking out of the Civil War.

Scientific Shipbuilding.—Scientific shipbuilding was greatly influenced by the laudable efforts of the Institution of Naval Architects of Great Britain, which earnestly addressed itself to this rapidly rising problem of establishing regular communication between Great Britain and the rest of the world. England was becoming an exporting country for manufactured products, and many of her people began seeking homes in America. She needed supplies from the outside world, and her shipbuilders early recognized the fact that her future well-being depended upon the upbuilding of an efficient merchant marine. Comprehensive and scientific rules of construction of ships were laid down and enforced by governmental supervision, and law after law was passed by Parliament to secure the greatest efficiency in Britain's water carrying capacity. "Unworthy" sea ships were excluded from the service.

American Shipbuilding.—Meanwhile, American shipbuilders were not idle, and shipyards were established at Philadelphia, Pa.; Bath, Me., and at other points. The Civil War, and the accompanying destruction of American shipping on the high seas by the Confederate war ship "Alabama," virtually crushed the ocean shipbuilding industry, and from which it has not yet fully recovered.

Coastwise requirements were for a long time, and still virtually are, the limitations of shipbuilding enterprise in the United States, though some excellent specimens of ocean-going steamers testify to the ability of American shipbuilders.

Where Ships are Built.—Successful yards are now established at various points, among them Philadelphia, Pa.; Bath, Me.; Elizabethport, N. J., and at points along the Delaware river below Philadelphia; at Newport News, Va.; San Francisco, Cal.; New London, Conn., besides many large yards along the lakes for the construction of craft for lake service, some of which are towering specimens of shipbuilding skill as to capacity, speed and economy of operation.

Marine Engineering.—Marine engineering has developed rapidly, and the mechanical equipment of ships has reached a superb degree of excellence in the production of a type which, for speed, safety, capacity and endurance under every possible condition of service, is scarcely to be excelled throughout the world. A powerful stimulus to American shipbuilding has been the necessity of providing transportation facilities along the Atlantic, Gulf and Pacific coasts and to Asiatic countries.

Ironclads.—The construction of ironclad vessels constitutes a most interesting feature in the grand chapter of shipbuilding. In 1842 Robert Stevens, of Hoboken, N. J., proposed a system of coast defense by armorclad vessels, which attracted world-wide attention, but his ambition was not realized. The Crimean War opened the way for ironclads. The French Government soon after ordered the construction of five floating batteries. England followed. Immediately great strides were made in naval construction throughout the world, which was followed by revolutionary improvements. A remarkable impetus was given to naval construction in 1862 by the introduction of radical changes, but it was the genius of John Ericsson, who in 1861 built the "Monitor," that transformed naval construction. From that date onward each successive war ship manifests some important improvement. Even to-day, however, doubts prevail as to the wisdom of the multiplication of immense battle ships as against the tiny torpedo boats, whose powers of destruction have never been fully ascertained.

Poor Shipping Facilities.—The insignificance of shipbuilding in the United States is seen in the fact that during the last decade only 206,771 tons of ships for foreign trade were built in our shipyards, as against 12,077,359 tons of steel steamships throughout the world, of which Great Britain built 81.1 per cent.

Shipbuilding in the United States.—Statistics gathered in 1900 show that during twelve months 2,087 vessels were built, consisting of steam, sailing, barges, and including canal boats. Tonnage, 687,681 gross tons. Of these, 519 were steam, 652 sailing vessels, 844 barges, 872 canal boats. Of the steamships, 134 were of iron and steel. Of wooden vessels there were 1,953. There are 122 establishments on the Great Lakes, employing from 8,000 to 9,000 men, engaged in ship and boat construction.

The iron and steel material entering into shipbuilding consists of steel, iron and steel plates, beams, angles, forgings, bolts, spikes, rivets, girders and castings. The value of these products used in shipbuilding in 1900 was $11,878,297, and amounted to approximately 180,000 short tons. The logs, timbers and knees used amounted, in board measure, to 267,953,000 feet.

The wooden shipbuilding industry is declining on the Great Lakes, excepting in Wisconsin. It is holding its own on the Atlantic coast, while on the Pacific coast it is advancing, owing to the proximity of large forests of shipbuilding timber. There is at times over $10,000,000 worth of work under process of construction at one time in the shipyards of the United States.

Opening Opportunities.—The industry is badly and sadly handicapped by lack of legislation, or, perhaps more properly stated, by a lack of popular understanding of the importance of the industry for the building up of a merchant marine. The American people have always been so intensely engaged in the development of resources on the land, that they have had very little thought for ocean traffic. New conditions, necessities and possibilities are now arising. The world is opening its ports for American productions, agricultural and manufactured. Our home markets, long equal to absorbing the great bulk of home production, may not prove much longer equal, because of the phenomenal expansion of productive capacity in all lines of activity.

Necessities Will Force the Issue.—The American people will ere long require the markets of the world to absorb their surplus products, and there will arise a demand for American-made and controlled ships to carry American products to the four corners of the world. It has been estimated—probably loosely—that American products pay to foreign vessel owners nearly $150,000,000 in freights. The possibility of adding this business opportunity to our own people is one of the sources of agitation in favor of American-made ships. The decision of this momentous question has assumed a political complexion, and there is no immediate solution of it in sight.

Coast Trade.—The coastwise trade is yearly demanding additional tonnage, and the probabilities of a large Asiatic trade by way of the Pacific has stimulated shipbuilding enterprise. Two vessels have been constructed, one of which was launched in the spring of 1904, of 35,000 tons capacity, the largest freight ship in the world. It is plying between Pacific and Asiatic ports in the service of the Northern Pacific Railroad Company.

The pressure of commercial necessities must ere long lead to a successful solution of this problem, and will result in the building of an American merchant marine that will make the United States probably the equal in tonnage to Great Britain.

The remarkable development of manufacturing and agriculture has created urgent necessities for coastwise transportation, and out of these conditions American shipbuilding is arising.

Comparative Summary of Shipbuilding in the United States for Three Decades.

	1880	1890	1900
Number of establishments...	2,188	1,006	1,116
Capital invested............	$20,979	$27,262,892	$77,362,701
Wage-earners...............	21,345	22,143	46,781
Wages paid.................	$12,713,813	$13,083,949	$24,839,163
Value......................	$36,800,327	$38,065,410	$74,578,158

Shirt Making.

History.—The use of the shirt as a distinctive garment receives scarcely any mention in early history, although outer garments of greater length were in common use in all ages. The shirt seems to have been especially used by the people of the northern countries of Europe as a protection against cold, and before the art of weaving reached any important proportions this garment was frequently made of skins.

Introduction of the Cotton Fibre.—With the discovery and utilization of the cotton fibre, skill was developed in the fabrication of this article of apparel, and its use became general. One of the first purposes to which cotton was put was in providing underclothing made of cotton, or cotton mixed in varying proportions with wool.

The cultivation of flax upon a more extended scale led to the use of linen in shirt making and resulted in a general substitution of a higher grade of textile material. The industry of shirt making has become an important one, especially in the United States, where personal standards of comfort and taste are affected by higher education and broader general intelligence. In New York and portions of New England large manufacturing establishments are devoted especially to the production of this class of goods and which are equipped with labor-saving appliances of remarkable efficiency.

Use of Linen.—The use of linen is quite ancient, and flax was industriously cultivated in many parts of the world for the production of textile fabrics to be worked up into shirts and shirting material. Great skill was attained in the domestic circle in the cultivation and preparation of the fibre and in the art of weaving it into material; in fact, in Europe the industry was quite an important one, and the art was followed by many in the higher walks of life, in order that the tastes of the wealthy might be gratified.

Comparative Summary of the Shirt Industry.

	1880	1890	1900
Number of establishments..	549	869	986
Capital invested...........	$6,841,778	$14,273,611	$20,273,611
Wage-earners...............	25,687	31,207	38,492
Wages paid.................	$5.403,626	$9,193,495	$11,425,101
Value of products..........	$20,130,131	$33,638,593	$49,022,845

The shirt-making industry has increased 300 per cent. since 1880, and the formerly restricted use of cotton and linen for shirting has become general. The spread of the industry is in a measure due to the abundant supply of cotton cloth.

Shoddy Making.

How Shoddy is Made.—Shoddy, which has become a significant term in its general application, has of late years attained a very important position in the textile industry. It derives its name from the fact that it was shed or thrown off in the spinning of wool. It came to be applied to old woolen or worsted fabrics when torn to pieces by a machine having spiked rollers, termed a "devil." It was cleansed and the fibre spun with certain proportions of new wool, the yarn being afterward woven into the full-bodied but flimsy fabric known as shoddy, which was made into cheap cloth, table covers, etc. It is generally used as a term to designate goods of a trashy or inferior character. The workers in it frequently, by inhaling fine particles, become affected with "shoddy" fever.

Comparative Summary of Shoddy Production.

	1880	1890	1900
Number of establishments..	73	94	105
Capital invested............	$1,165,100	$3,754,063	$5,272,929
Wage-earners...............	1,282	2,155	1,925
Wages paid.................	$400,326	$707,099	$748,948
Value of products..........	$4,989,615	$7,887,000	$6,730,974

Show-Case Making.

Show-Cases for Display.—The retail trade of the United States has created quite a demand for show-cases wherein goods of fine quality or texture are displayed for sale, where they may be temporarily protected from deteriorating influences of dust, dampness and sudden changes of temperature. Show-cases are also used as interior ornamentation and finish and for the more effective display of certain classes of goods. The glass used is of special manufacture and remarkably pure, and is bent into desired shape by special machinery, by which the desired curvature is mathematically given.

Uses.—The use of show-cases has become quite general in well-conducted retail establishments, and serves the valuable purpose of enabling merchants to present to the eye of patrons the attractive features of the goods displayed. In some retail establishments entire rooms are transformed virtually into a show-case, and the effect is heightened by the arrangement of electric lights to properly dazzle the feminine eye and thus forcibly appeal to the reluctant pocketbook.

Comparative Summary of the Manufacture of Show-Cases.

	1880	1890	1900
Number of establishments...	93	99	102
Capital invested............	$341,970	$1,208,022	$1,152,898
Wage-earners...............	692	1,331	1,363
Wages paid.................	$329,230	$718,102	$708,211
Value of products..........	$1,172,174	$2,569,577	$2,467 901

Signal System, Automatic Block.

Introduction of Signaling.—The rapid movement of passenger trains has necessitated the establishing of methods of continuous communication for the purpose of insuring safety in travel and means for knowing the actual location of trains as may be desired throughout the railway systems.

Various Systems.—The system of signals was introduced a generation ago, but at first the experiments and devices were extremely crude and unsatisfactory. Within the past two decades various systems of signaling have been brought to a condition of highly practical efficiency, through the development of the block signal system.

Development of the System.—Devices are employed by which each train, on entering a "block," records entry; in this way the movement of trains is under control of central authority, tower men or the proper official intrusted with the movement of trains. The system has been worked to a very high degree of exactness along scientific lines, and the steps by which these results have been accomplishd are extremely interesting. Many of the leading railroads have adopted the block signal system of communication in a greater or less degree, and it is only a question of time when the system will be in practically universal use.

Eliminating the Personal Factor.—The objective point of railway managers is to secure an automatic system virtually independent of the personal factor, by which trains will themselves announce their arrival at each block. The efforts in this direction are very full of promise.

Many Devices.—A large number of patents have been issued for automatic devices, but few of which have stood the severe tests of actual practice and the exacting demands of railway managers. Among these devices may be mentioned a train-order signal device for a locomotive, which sounds an alarm as the locomotive approaches a stopping-point, and follows it up with an application of the air-brake if the engineer does not answer the call.

Interlocking Devices.—Improved signals and devices for interlocking with associated switches have been introduced, and these inventions are being favorably considered by various railway systems.

Operating Through a Cycle of Movements.—There are various switch and signal mechanisms adapted to be operated through a cycle of movements, having a minor system of return signaling from each switch or signal to the operating station, and which indicate the set positions of the same and insure operation in proper order.

Switches.—There are other means for assembling the operating levers of a complex plant of switches and signals in a single cabin and interlocking them, which devices are the subjects of numerous patents, all of them of very high and most commendable ingenuity.

Numerous Devices.—It would be impossible to enumerate even the more meritorious of these most numerous devices. The railway managers of the country welcome all devices and submit them to the careful scrutiny of their experts, and adopt those which are demonstrated to be practically efficient.

Progress.—The entire railway management of the country is; through self-interest and far-seeing wisdom, placing the railroad mileage of the country under automatic block signal protection, to the greater safety of the traveling public and to the financial advantage of the railroad companies.

Silk and Silk Goods.

Early Manufacture.—The Chinese made and wore silk ages before the outside barbarian world knew of its existence. They cultivated the silkworm extensively, and no inconsiderable part of the apparel of the wealthier and official classes consisted of artistically woven silk. The first Greek writer who speaks of silk was Aristotle, B. C. 384. Pliny also speaks of it, but the strenuous early Romans despised it to such a degree that in the reign of Tiberius a law was passed that no man should disgrace himself by wearing a silken garment. The Emperor Heliogabalus broke over this law and wore silken garments, and his example was followed by all classes who could afford them, and to the extent that they could be imported from China.

Foothold in Europe.—Two Persian monks, in A. D. 551, residing in China, encouraged by Justinian, carried the eggs of the moth to Constantinople, after which the industry took root in Europe. It was introduced into Sicily in 1146, then into Italy, next, in 1253, into Spain, next to Lyons, which early became the most important silk center of Europe. The refugees from Antwerp introduced silk culture into England in 1585.

Initial Processes.—When two or more threads are twisted together it is called a strand, and when so used in weaving it is termed the shoot or weft. Thrown silk is formed of two or three or more singles twisted together in a contrary direction to that in which the singles of which it is composed are twisted. This process is termed organzining, and the product, organzine.

The Cocoon.—Silk cotton is a short, silky, elastic fibre obtained from the bombax tree, and the Hindoos make it into a coarse, loose cloth. The silk-producing caterpillar, when full grown, is about three inches long, with hornlike projection. The cocoon is about the size of a pigeon's egg. The perfect male insect is about an inch long, with a wing expanse of two inches; the female is a trifle larger. There are eleven varieties.

Spread of Silk Culture.—The Spaniards introduced silk into America, and "seed" was sent to the Jamestown colonists. Notwithstanding the failure of many early efforts at silk culture, 6,000 copies of a book on silk culture were printed by order of Congress in 1826, to educate the people in silk culture. Silk conventions were soon after held in several States, and a period of speculation followed, but the "silk bubble" subsequently burst.

Methods.—During the past ten years the problem of spinning, doubling and twisting organzine in one process has been solved by the production of a practical machine. Among the later improvements in machinery are the numerous multipliers, two-weave, leno, swivel, embroidery motions and other devices designed to operate automatically. The two-weave multiplier is a very important device, by the use of which two distinct weaves are produced in the loom and indicated from the same pattern chain. The manifold multiplier, when used in addition to the two-weave motion, makes it possible to produce three or more distinct weaves in the same weave, each weave being distinct from the others. There is practically no limit to the number of weaves by the use of this mechanism, the change from one weave to the other being made automatically when the loom is in full operation.

Improved Mechanical Devices.—Various devices are employed to produce leno effects, and the lap-pet motion has been successfully applied to different types of looms. The embroidery loom is designed to produce a figure on a light ground of cloth while the cloth is being woven without waste of stock. By the swivel looms as many as three colors can be put in each figure at will. The highest type of loom for best grades of fabrics is fitted with a positive head motion. In the Jacquard loom the present double-cylinder cross-border machine accomplishes about the same result on the loom as does the manifold multiplier.

Comparative Summary of the Silk Industry.

	1880	1890	1900
Number of establishments...	382	472	483
Capital invested.............	$19,125,200	$51,007,537	$81,082,201
Wage-earners................	31,337	49,382	65,416
Wages paid..................	$9,146,705	$17,762,441	$20,982,194
Value of products...........	$41,033,045	$87,298,454	$107,256,258

Silk and Silk Workers.

Silk Culture.—Silk culture was introduced into the United States under the patronage of Benjamin Franklin and others in 1750, who opened an establishment for reeling silk from cocoons. At that time and prior thereto considerable quantities of sewing silk were made in families by primitive appliances. Susanna Wright, of Columbia, Pa., in 1770 offered prizes for reeling and weaving silk from home-grown cocoons, and a piece of "mantua" sixty yards long was produced. In 1793 the making of fringes, coach laces and tassels was begun in Philadelphia, and by 1815 the industry had expanded to produce silk trimmings, naval sashes, ribbons and braids. Power-loom weaving was introduced in 1837 for weaving ribbons from narrow goods. One establishment in Philadelphia turned out gold lace several years before its manufacture was attempted in Europe. Excellent black silk plush was made in Philadelphia in 1831, and silk vestings were made at Economy, Pa., by a German sect. Sewing silk was made in Massachusetts in 1790, and soon after coach lace. For many years after the industry was discontinued, but was again revived along manufacturing lines.

Development of the Industry.—America now produces about 85 per cent. of the annual requirements for silk ribbons. The classes of silk now imported are high novelties, silk velvets and hand-made silk laces. The industry has undergone many changes since 1850. The demands of fashion, the adaptability of silk to fancy designs, and the varying proportions in which silk may be used with other material in fabrics of all kinds, have resulted in an almost infinite variety of products. Much of the silk spun is now consumed in cotton and woolen mills, while silk mills absorb large quantities of woolen and cotton yarns.

Sewing Silk and Machine Twist.—The sewing silk and machine twist made in the United States is acknowledged as superior in finish and purity of dye to that of any other country, because only the best Japan and China filatures, dyed unweighed, are used. It is noteworthy that the Grand Prize was awarded at the Paris Exposition in 1900 to an American for the best silk.

Changes in Methods.—Among the important changes in methods in the silk industry during the past decade were an increased use of machine twist for manufacturing purposes, and a tendency toward finer sizes of threads. Two-thirds of the output of machine twist is sold to manufacturers of clothing, shoes and cloaks, one-third being sold to the dry goods trade, such as spool silk for the retail dressmaking trade. The manufacturing trade absorbs about one-half of the sewings, the remaining half being sold as embroidery silk, knittings and wash embroidery silks. The sale of embroidery silks for embroideries and decorative purposes has increased phenomenally.

Lustre and Evenness of Thread.—The lustre and evenness of the thread have been improved, fineness of the twist has been increased, and there is a greater variety of brilliant, plain and sombre colors, perfectly blended. In sewing silks alone a full assortment of colors now runs up to two hundred.

Spool Silk.—Forty years ago sewing silk was put up in skeins, but with the introduction of sewing machines, fully 99 per cent. of all machine and sewing silk is put up on spools. Another improvement is the decided tendency toward finer sizes of thread. Formerly the average size used was known as Size A, representing 1,000 yards per ounce. To-day the principal goods sold represent 1,600 yards to the ounce.

Silk Taffetas.—The production of silk taffetas in both black and colors by power looms was first introduced in the United States and later into Europe, and foreign countries are now close competitors with us. The greatest bulk of high-class "fancies," which formerly were imported in quantities, are now made at home, in every variety of checks, stripes and Jacquard patterns in popular grades. Marked progress has been made in the manufacture of piece-dyed goods woven with raw-silk warps. Warped print fabrics are largely manufactured here both in broad silk and broad silk ribbons. Our warp print goods, including silk ties, command admiration in Europe. A striking feature of the industry is its increase in the number of power and hand looms.

Silk Power Looms.—The increase of silk power looms and decrease of hand looms has been marked. The increase from 1880 to 1890 was from 3,103 to 36,825 on broad goods, and from 2,218 to 7,432 on narrow goods. Hand looms on broad goods decreased from 1,629 in 1880 to 164 in 1900, and on narrow goods from 1,524 to 9.

Seal Plushes.—Seal plushes at first very popular in the cloak, cape, cap and trimming trades, have largely gone out, because of the increasing cheapening, until fashion no longer favored them. The development of broad-goods weaving increased nearly tenfold between 1880 and 1900.

High-Speed Ribbon Looms.—The invention of the high-speed ribbon looms, first made in the United States, was a marked advance over European methods of manufacture. Its marked features are ease in leveling the harness, handling the warps, and the positive control of the take-up, which enables the looms to be run at continuous high speed, which work is mainly done in our factories by women. The equipment of ribbon-making machinery is now most complete.

Materials.—The materials used in the manufacture of finished silk are raw, spun, artificial and waste silk, cotton, cotton mercerized, wool and mohair yarns, and partially manufactured silk made from organzine.

Products.—The products into which it is manufactured are finished organzine and tram, spun silk yarn, machine twist, sewing, embroidery and wash silks, fringe and floss silks, broad silk goods, plain and fancies, silk mixed goods, Jacquard silk, piece-dyed goods, plushes, velvets, tapestries, upholsteries, ribbons and laces, nets, veils and veiling, gimps, braids, bindings and trimmings.

Spindles.—The number of spindles recorded in 1900 were 1,987,404; 44,257 power looms, 173 hand looms, besides machines for crotcheting, roundhead machines, beamers, braiders, chenille machines, curtain machines, embroidery machines, gimp, levers, sewing, slide-cord, twist and warping machines.

There are 115 silk-ribbon weaving mills in the United States. American "throwing" is done principally on belt spinners, which are run from 11,000 to 12,000 turns a minute on first time over, and 9,000 on second time over.

Silversmithing and Silverware.

Silver.—The use of silver as money and for ornament is coeval with earliest civilization. Silver is spoken of as a medium of exchange in Genesis. The art of the silversmith is based on the use of silver, and the art was among the earliest developed. The records and evidences of the early uses of silver, especially for ornamentation, are numerous and interesting. Silver exists in most countries, but the larger deposits are in the United States and Mexico. The total production of the world varies from year to year, but it is generally approximated at $160,000,000.

Decline in Price.—The discontinuance of silver as a standard currency, except as a minor currency, has caused a marked depreciation in its value, which has made it more available for other uses. The art of the silversmith is demonstrated in a great variety of work in which originality of design, coupled with exquisite workmanship, is producing many articles of household use. Considerable silver is consumed in the plating of ware, and the business has become an important and profitable one.

Three Extracting Processes.—There are three processes in the extraction of metallic silver from its associated minerals, viz.: when it is amalgamated with mercury or alloyed with lead, when it is recovered by oxidation, and when it is converted into a salt, brought into solution, and precipitated in metallic form by means of copper. This is termed the "wet method."

Frosting.—Commercial silver is never pure, traces of copper and gold being invariably found. A frosted appearance is given to standard silver articles by the silversmith by heating until a thin skin has had its copper oxidized, then removing this oxide by immersion in ammonia or dilute sulphuric acid, which allows only pure silver to show.

Comparative Summary of Silversmithing.

	1880	1890	1900
Number of establishments...	38	24	44
Capital invested............	$76,640	$198,778	$803,662
Wage earners................	131	274	1,427
Wages paid..................	$257,198	$410,773	$1,999,921
Value of products.........	$263,931	$621,562	$2,936,462

The value of the silverware produced in 1900 was $10,569,121, or double that of 1890, and four times the product of 1880. The consumption of silver in the arts is steadily increasing and sources of supply are being continuously opened up. The cheapening cost of silver, the growing taste for silverware in the household, the increasing skill of the silversmith and the introduction of more economic appliances and methods in the production of ware all unite to increase the output of this interesting branch of industry.

Skins, Animal in the Arts.

Animal Skins.— The whole world is being rummaged, as it were, for skins of animals for innumerable decorative and utilitarian purposes. Each species of skin has its own peculiarities. In some there are long fibres, either interlaced or running in parallel rows.

Sheep Skin.—Sheep skin, for instance, has larger fibres than any other material used in the manufacture of shoes, and excels all other materials for trimming. It is also used for fancy work, pocketbooks, traveling-bags and similar manufactured articles, as it will absorb any color which may be given the most delicate shades.

Goat Skin.—In goat skin the fibres are shorter and generally criss-cross, which gives a greater degree of strength; having a finer and firmer tissue, it is more durable than sheep skin. It was formerly used only for tops and quarters in men's wear and for slippers and low cuts for women and children. Goats are found in various parts of the world, and because of the expanding demand, prices are advancing. The goat sheds its hair once a year, and is most wanted when the new crop reaches full growth.

Calf Skins.—When calf skin is finished on the grain it is used for all parts of the shoe, and when finished on the flesh side it is used only for vamps, quarters and tips, for which purpose it is unequaled. It may be crimped to any desired form without becoming inflexible and without wrinkling, with the exception of the flanks, which are inclined to looseness. All parts of this stock have a tough surface.

Hides.—Among other animals whose hides are used may be mentioned the kangaroo, porpoise, seal, alligator and horse. The hide of the latter animal is known in the market as "Cordovan." The stock of Cordovan is obtained mainly in South America, where wild horses are captured in large numbers. Only a part of the hide of the horse, taken over the rump, is used for leather. It is an oval piece about three feet long and half as wide, and possesses nearly twice the strength of calf skin. The leather is more waterproof than that of any land animal. Tan and russet are made of horse hide.

The Kangaroo.—The grain of the kangaroo skin is fully twice as thick as that of any other skin of its size and weight, while the thickness of the whole skin varies greatly according to the size of the animal.

The Alligator.—Next comes the alligator. The supply comes from Central and South America mainly, and the only skin used is from the under side of the hide. The covering of the back is composed of hard, brittle scales. Most of the tanning is done in Massachusetts. The demand for alligator skin has stimulated the business of gathering the raw material, which is quite an exciting one at times, especially when the possessors feel they have further use for their skins. The skin of the porpoise affords a tough leather much used for shoestrings.

Slaughtering and Packing Industry.

Cattle in the Colonies.—Cattle were imported by Columbus on his second voyage to the West Indies in 1493. The Portuguese in 1553 carried cattle to Newfoundland and Nova Scotia. Cattle, swine and sheep were introduced into Florida in 1565, and into Canada in 1608, by the French. In 1609 the English colony at Jamestown, Va., possessed between 500 and 600 hogs and some sheep. By 1630 they had 500 cattle, and in 1649 the number had increased to 20,000. Frequent shipments were made to New England, as well as to London, Bristol and Amsterdam, as early as 1656. About this time a good trade had been developed between the colonies and the West Indies in beef, pork and bacon. The Indian wars made the possession of live stock precarious throughout the colonies. In 1678, 400 cattle were dressed in New York, and in 1694 the annual slaughter had increased to 4,000.

Stock in the West.—Early in our history stock-raising became an important occupation in the Far West. Stock was gathered from Spanish America and from the East, and thus laid the foundation of the great Western cattle-raising industry of to-day.

Rise of the Slaughtering Industry. — The slaughtering and packing of meat became an industry in 1818, the first establishment being located at Cincinnati, Ohio. Slaughtering began in Chicago in 1823, and packing in 1827. In 1834, 9,600 hogs were slaughtered in that city, while about the same time the slaughter in Cincinnati amounted to 85,000 hogs. Plants sprang up in all the important cities throughout the West. By 1850 the annual slaughter in Chicago amounted to 20,000, and at that time the figures for Cincinnati were 500,000. Nature, however, favored Chicago, by reason of its water connections and railroad facilities to obtain supplies and deliver products, and the industry grew with amazing rapidity.

The Union Stock Yards.—The Union Stock Yards in Chicago were established in 1865; the invested capital in 1900 was given at $67,000,000, employing over 50,000 men. These yards, in 1900, covered over 200 acres, with over 30 miles of streets, 30 miles of water trough, 100 miles of drainage and water-pipe and upward of 200 miles of railroad track. The facilities have since been greatly expanded.

A Leading Event.—An important event in the slaughtering industry was the introduction of artificial refrigeration and of refrigerator cars, the latter of which was due to the inventive ability and enterprise of William Davis, of Detroit, Mich. The adoption of the refrigeration car made it possible to slaughter cattle in the West, and Western packers were quick to meet the requirements.

Wastage.—In the early history of the slaughtering industry but little attempt was made to utilize waste. Blood was allowed to drain away, and many valuable products were carted away or buried. Enterprising business men, however, soon saw opportunities for profiting by this waste, and industries sprang up which utilized practically every particle of previous waste, such as horns, hoofs, blood, bones, sinews, hide and trimmings, in the production of glue, gelatine, brewers' isinglass, curled hair, bristles, wool felt, hair felt, laundry soap, soap powders, toilet soaps, glycerine, hydrous ammonia, fertilizers, dried blood, bone meal, cut bones, poultry food, albumen, neat's-foot oil, pepsin, knife handles and many other products.

Arrival of Stock at Yards.—As soon as possible after arrival of stock at yard the herds are driven to pens, watered and fed, which is followed by examination and weighing, after which the animals are driven to the slaughter-house. On account of their worry and exhaustion, about twenty-four hours are allowed them to become familiar with their surroundings. Hogs are an exception. They are sprinkled and driven to a large solid wheel which has chains fastened at intervals along the rim. To each chain a hog is shackled by one hind leg; the wheel revolves, raising the squealing porker. At the top he is automatically detached, and a hook attached to the sloping rail carries the victim to the butcher, who cuts the throat lengthwise, after which the blood is drawn off and the carcass plunged into a bath of scalding water. Automatic machines are then employed to remove the bristles, which is done far better than by hand. Next the head is nearly severed, the gambrels cut and the body suspended by them from the rail.

The Next Step.—After an interval the body is opened and dressed, leaf lard removed, head detached, tongue removed and the body split in two, all of which is done at the rate of twenty hogs a minute. In fact, one might imagine the hogs had hardly time to die before they find themselves cut into pieces. Two halves go to the chill room, where the animal heat is abstracted. Next the halves are run to cutting tables, and the various parts intended for curing are sent by chutes to curing rooms, where they lie longer or shorter periods in dry salt. Those intended for smoking lie in vats of sweet pickle from five to eight weeks. They are then removed to the soaking tank for twenty-four hours, in order to make the salting uniform. From here the hams go to the trimming table, thence to the smoke-house, and afterward to the storeroom.

Sausage.—The manufacture of sausage is made of trimmings, the remnants of everything from the trimming department, the butcher's bench at the market stall, from the killing room, the beef houses particularly, where the heads and hoofs are trimmed. This meat is chopped, mixed and stuffed by machinery, in which spices, such as sage, pepper, salt, ginger and mustard, are mixed with the meat prior to its passage through the chopping machine. The ginger and mustard counteract the action of the fatty greases in the stomach. Potato flour is added to give consistency to the material. At this point the mixture consists of 40 per cent. meat and spice, 40 per cent. potato flour and 20 per cent. water. The potato meal neutralizes the taste of the pork, and the spices facilitate digestion.

Stuffing.—Automatic machinery is employed to utilize the intestines, the best machine having a pressure of 190 pounds to the square inch in the stuffing cylinder. This causes sufficient pressure to force the sausage from the small orifice at the cylinder, to which is attached a tube, over which the sausage casings are slit, and the pressure of the cylinder when filled is sufficient to fill the skins at a speed of a mile a minute. Talk of express trains!

The Killing of Cattle.—Returning to the poor cattle awaiting unconsciously their fate, a day of grace is generally allowed for them to prepare for exit to cattle heaven. After they have cooled off they are driven up an incline to the top of a four or five-story building, into a long, narrow lane of a width to allow only two cattle to stand abreast; as the two animals in the lead reach the end of the lane, a partition is lowered between them.

This process is repeated with the next pair, and so on until the end of the line; the line of cattle being thus secured, attendants wielding a heavy hammer traverse a platform that runs along outside near the top of the lane, and with a swinging blow hit the animal above the eyes. The side of the lane is then raised, its floor tilted, and the carcass precipitated upon the slaughtering floor. The body is then shackled by the hind legs, hoisted and hooked to a rail, along which it slides to the butcher, who with a quick thrust severs the large vein of the neck. The blood is collected into a large tank; the carcass is beheaded, lowered to the floor, and the hide removed by a number of workmen, each of whom detaches only a small part of the hide. The beef is then sent to the chill room, where it is refrigerated forty-eight hours when it is intended to be used as fresh meat, and is then run to the loading platforms, is divided into fore and hind-quarters, and loaded into refrigerator cars for shipment to all parts of the United States and foreign countries. The killing of sheep differs but little from the killing of cattle.

Canning.—The meat used in canning is generally cow beef and of an inferior grade; it is cooked in huge kettles, and is handled with pitchforks. As soon as cooked it is automatically pressed into cans, which are capped, soldered, sealed and inspected by steaming. The cans are washed, painted and labeled, and the work is done.

Inspection.—All animals intended for slaughter are examined by a government inspector. Those unfit for slaughtering are condemned and marked with a metal tag stamped "U. S. condemned," in the ear. At the time of slaughter all animals are again examined, and if found diseased the carcass is marked with a yellow condemnation tag and removed from use. Each article of food made from inspected carcasses must bear a label on which appears the official number by which the establishment is known to the Department of Agriculture. A copy of this label is filed with the department. Each package shipped has stenciled upon it "For export" or "For interstate trade."

Growth of Slaughtering.—In 1891 there were 9 abattoirs in 6 cities in which were slaughtered 83,889 cattle. In 1892 there were 28 abattoirs in 12 cities in which were slaughtered 3,167,009 cattle, 59,089 calves and 583,361 sheep. By 1896 the number of abattoirs had increased to 102 in 26 cities in which were slaughtered 3,985,484 cattle, 256,905 calves, 4,629,796 sheep and 14,250,191 hogs, making a total of 23,122,376 animals. In 1900 the number of abattoirs had increased to 148 in 45 cities in which were slaughtered 5,530,911 cattle, 9,150,490 sheep, 30,654,333 hogs and 5,559 horses, making a total of 45,381,293 animals.

Comparative Summary of Slaughtering, Meat Packing and Retail Butchering.

	1880	1890	1900
No. of establishments	872	1,367	1,134
Capital invested	$49,419,213	$118,016,066	$190,706,927
Wage-earners	27,297	44,812	69,441
Wages paid	$10,508,530	$24,668,202	$33,923,253
Value of products	$303,562,413	$564,667,035	$790,252,586

Slot Machines.

A New Industry.—One of the inherent traits of human nature is the disposition to get more for less, as well as the love for taking chances. This has built up an industry for the manufacture of what are termed slot machines, which has grown to quite large proportions within a very few years. Slot machines are a convenience, enabling small purchases to be made without the intervention of personal agency and without the delay of waiting for packing or change. These machines have become very common in stores and public places and serve a useful purpose. The ingenious mechanical adaptations, by means of which goods are dealt out in packages in slots upon the deposit of a definite price, are highly ingenious and creditable to inventive ability.

Purposes Served.—Slot machines are constructed somewhat after the mechanism of clocks, and have been installed in public places, bar-rooms, barber shops, hotels, stores and other places, in many cases for gaming purposes, but many small machines are adapted to hold small confection packages, which are released successively upon the deposit of a coin. Slot machines are also in increasing use in households, serving the purpose of a gas meter by the depositing of a coin, and which are regulated to release gas at corresponding value. There is a multiplicity of purposes to which these machines can be applied, and their popularity is assisting in their increasing use.

Smelting and Refining Industry.

Industrial Importance of the Metals.—Lead, copper and zinc stand in intimate relationship to many of the industries of the United States. They might in one sense be regarded as the hub of the wheel of industry. From the standpoint of industry they play a most important part.

Progress of Smelting.—The lead smelting industry has made remarkable progress during the past decade. Of the 39 lead-smelting establishments in the United States, 34 are located west of the Mississippi, which represent 87.6 per cent. of the capitalization of the industry. Colorado leads in lead smelting, while Missouri leads in the smelting of soft lead ores, and furnishes 92.8 per cent. of the total output.

The Home of Smelting.—The smelting of argentiferous or silver-bearing ores is centered largely in Colorado, Utah and Montana, while the refining and desilverizing is conducted largely in New Jersey, also to some extent in Kansas and Nebraska. A modern smelter represents a high type of engineering skill, metallurgical talent and constructional capacity. The developments in chemistry and metallurgy are here practically applied to the easiest enticement of atoms of minerals hidden in quartz and rock to come out of their hiding-places to serve the requirements of man. These powerful smelting plants might in one sense be regarded as huge chemical laboratories where transformations occur which draw to the service of man those metals of which he stands in such great need for scores of uses. The story of the miner's work in delving into the bowels of the earth, often in the face of dangers of which daylight labor knows naught, is full of exciting interest.

The Smelter a Mechanical Stomach.—The smelter is a mechanical as well as a chemical stomach. It is constructed in strict accordance, mechanically, with the requirements of the work of separation of elements and materials. A knowledge of the nature of such metals is an absolute necessity, and experience and studious investigation are demanded. The industrial requirements of the country have greatly stimulated the construction of smelters, and they are being built in many localities more and more remote from older mining regions.

The World's Need.—The world needs lead, copper, zinc, silver and gold in increasing supply. Civilization measures the sureness and regularity of its steps by the supply of these products. The world's mouth is wide open for gold. Its demands are driving hardy pioneers into remote regions in search of it to serve the urgent needs of trade, manufacture and the arts. Silver has played an important part in the world's progress, but the best interests of commercial society appear to require that gold be made the basis of exchangeable values, though the more backward nations, such as India and China, use silver in their domestic exchanges.

Demand for Copper in the Electrical Industries.—The electrical industry is making enormous demands upon copper producers, and within a few years the mining of copper has attained phenomenal proportions. The ocean bottoms carry cables; the land is covered with appliances and equipments to conduct power, wherein copper plays a most important part. New and extensive deposits of copper are being located, and vast sums are being expended in the opening up of these deposits and in facilities for their best equipment for the greatest production.

Smelting Follows Supplies.—The progress of smelting and refining in the United States bears a correspondence to our industrial development, and especially to railroad expansion and the growth of the electrical industry. The smelting industry is now thriving and is extending with giant strides into new regions where enormous deposits of lead, copper, zinc and other metals are found.

Zinc.—The zinc industry of the United States is divisible into two groups, western and eastern; the western group depends on ores mined in Indiana, Illinois, Wisconsin, Missouri and Kansas, while the eastern group, located in Pennsylvania, New Jersey and Virginia, controls and owns its own ores.

Production of Lead.—Production of refined lead increased from 42,540 tons in 1873, to 47,825 tons in 1880, 161,754 tons in 1890, and 304,392 tons according to the census of 1900. The cost of materials used in the lead-smelting and refining establishments in 1900 was $169,703,366. The cost of refining was $100,802,504.

Production of Copper.—Production of copper in the United States increased from 100 tons in 1845, to 650 tons in 1850, 7,200 tons in 1860, 12,600 tons in 1870, 27,000 tons in 1880, 115,966 tons in 1890, and 253,870 tons in the census year 1899. Since that year production has considerably exceeded these latter figures.

Summary Showing the Condition of the Lead-Smelting and Refining Industry in 1900 (Census Figures).

Number of establishments	39
Capital invested	$72,148,933
Wage workers	8,319
Wages paid	$5,088,684
Value of products	$175,466,304

Summary of Copper Smelting and Refining in 1900 (Census Figures).

Capital invested	$53,063,395
Wage workers	11,324
Wages paid	$8,529,021
Value of products	$165,131,670

Summary of Zinc-Smelting Industry for 1900 (Census Figures).

Number of establishments	31
Capital invested	$14,141,810
Wage workers	4,869
Wages paid	$2,355,921
Value of products	$18,188,498

Sports and Pastimes.

Varieties of Sports.—Among leading sports may be enumerated base ball, foot ball, automobiling, rowing and golf. In golf last year American teams won eight out of ten matches, squared one, and lost the other, against a team of Oxford and Cambridge (England) players. Polo has become popular, and practically every army post has its polo club. Fencing is enjoying a boom. Whist retains its popularity, and the American Whist League has a membership of 30,000. Field and track athletics engage much attention. Walking matches are on the increase, and jumping is gaining adherents. Latest swimming records are highly creditable to American skill, and boxing is gaining ground. Among other games of increasing popularity are lawn tennis, racquet, court tennis and squash, cricket, basket ball, coursing, hand ball, wrestling, chess, bowling, curling and trap shooting. In this last game the elimination of live pigeons as targets has brought hundreds of new shooters into the game.

Interest in bowling has suddenly increased. The national organization of bowlers has split over the point as to weight of ball, the Eastern branch clinging to an 18-pound ball with lead, the West holding out for a 16½-pound ball. Bowling alleys have been built in all the larger cities during the past few years.

Basket ball, which originally began in the lower educational institutions, and was played chiefly by women, has now extended to college men, military organizations and athletic clubs.

The game of cricket is enjoying a boom in intercollegiate circles. Tennis and racquet courts are steadily increasing, and they are becoming popular with a large number of sportsmen. During 1903 a building costing $250,000 was erected in connection with Columbia University, New York, to be used exclusively for physical culture. The subject is now receiving wide attention in various educational institutions and in organizations. It is recognized more and more clearly every day that certain mental and moral qualities which can be developed through a comprehensive pursuit of health are essential for the highest efficiency of the individual.

There is a general recognition that sports afford a development of mind and body not to be attained through any other avenue, and to that end rational sports are being widely introduced and popularized.

Comparative Summary of the Sporting Goods Industry.

	1880	1890	1900
Number of establishments	86	136	144
Capital invested	$1,444,750	$1,693,776	$2,018,737
Wage-earners	1,401	2,008	2,230
Wages paid	$411,854	$705,911	$810,943
Value of products	$1,556,258	$2,709,449	$3,633,396

Increase.—The manufacture of sporting goods has increased one hundred and fifty per cent. in twenty years. Sports and "pastimes" have increased until now there are upward of a full hundred different methods of in-door and out-door diversions and enjoyments. Each game has its own paraphernalia or accoutrements, for the manufacture of which special skill is necessary and special machinery employed. Some two hundred special lines of goods are manufactured by over thirty different industries, into which wood, rubber, leather, celluloid and textile products enter.

Side Lines.—The production of many lines of sporting goods is carried on in some large manufacturing establishments as "side lines," but there is an increasing number of establishments especially devoted to the manufacture of sporting goods alone and which has resulted in the establishment of separate retail stores where all the various lines of sporting goods and games are sold.

Interest in Sports.—The industry has grown rapidly because of the greater attention given to sports, growing, as measured by the number of establishments, from 86 establishments in 1880 to 144 in 1900, and as measured by value of products from $1,556,258 in 1880 to $3,663,396 in 1900. In the latter year over 2,000 workmen were exclusively engaged in the factories especially engaged in the manufacture of the various lines of goods.

Special Clothing.—An important accompaniment of sporting is the stimulus imparted to the manufacture of special kinds of clothing used while engaged in sport. The golfers have their special suits for both male and female players. Polo players are especially fitted for that form of exercise. Athletes have their particular clothing designed for protection and to permit freedom of body and muscular movements; base-ball and foot-ball players wear clothing especially adapted to the requirements of those games, and nearly all others who engage in sports adopt some sort of clothing to permit of freer body movement.

Exception.—These remarks, of course, do not apply to many of the in-door games which form an important part of sporting enjoyments. Although not strictly coming under that designation, they belong, perhaps, more properly to pastimes, such as games of cards, chess, etc. Interest in sports is a favorable sign of the growing intelligence and broader cultivation of the people. Sports are educational in their influence and serve as a balance wheel as against the influences and effects that are developed in the strenuous life to which Americans are especially devoted.

Springs—Steel, Car and Carriage.

Use of Springs.—One of the first devices which mechanics sought to introduce, as soon as they succeeded in producing vehicles or primitive means for personal transportation, was something to sustain and transmit, and thereby reduce the shocks incident to traveling over roads or uneven surfaces. Wooden devices made of wood possessing elastic qualities were first used in baskets and vehicles which were first carried by men, and used to some extent by royal personages.

Leather Employed.—When the art of making leather was introduced and the carriage-building craft arose, leather was used to form springs, which extended under the body from fore part to the rear. This method was followed until a comparatively recent date, and is still followed in remote localities.

Steel in Spring Making.—The development of steel making during the past century introduced an epochal feature which revolutionized all previous means of furnishing easy riding. The use of springs is now extended to very many vehicles for the transportation of passengers and freight, from the ponderous locomotives to the lightest carriage. Springs arrest the disintegration of material, and by receiving the jarrings incident to rapid movement of vehicles, not only arrest the crystallizing of iron and steel and the loosening of nuts and bolts, but they also minimize wear and tear on roadways. The art and science of properly constructing springs to do their maximum work with a minimum of material is even now only partially comprehended, and much investigation and experiment is being conducted in testing establishments and in spring-manufacturing establishments, to arrive at scientific and practical conclusions.

Carriage springs are usually made of steel of a varying number of pieces, each successively shorter than the under one, firmly attached together after bending into desired shape and then attached to proper supports to receive the superimposed weight. Vehicles usually have front and rear, and often side springs, to transmit their weight equally and without jar. Car springs are composed of steel of vastly greater power, of different shape and construction and capable of enduring the heavy superstructure. These springs are the subject of many patents and their manufacture constitutes a separate and important industry.

Comparative Summary of the Spring Industry.

	1880	1890	1900
Number of establishments..	59	57	48
Capital invested	$1,762,293	$3,459,422	$4,684,228
Wage-earners................	1,530	1,734	2,102
Wages paid..................	$699,412	$962,942	$1,061,006
Value of products..........	$3,654,862	$4,331,571	$5,690,499

Starch Manufacture.

Uses of Starch.—Starch is found in almost every plant; it is a glittering white powder, soft, tasteless and insoluble in cold water. In the United States, Indian corn is the principal cereal employed in making starch for commercial purposes. Its most general uses are for laundry purposes, for the manufacture of glucose, for edible purposes and in the textile industries. It is abundantly found in cereals and potatoes, but five-sixths of the commercial starch of the country is obtained from corn. The method of manufacturing produces either starch or glucose.

Methods of Manufacture.—No. "2" grade Indian corn is used, the cob and leaves being removed in a sieve, dirt and dust by fans, and nails and iron scraps by magnets. The corn is steeped and softened in large tanks made of wood, iron or copper, usually with a capacity of about 1,000 bushels. Water charged with three-tenths of 1 per cent. of sulphuric acid, heated to 125 degrees Fahr., is used for softening the grain, the water being circulated from the bottom to the top by means of a steam injector, 24 to 36 hours being required for the purpose.

Cracking and Grinding.—The soft, warm grains are cracked with burr mills, and then ground only enough to loosen but not break the germ. The mass is then threshed three times to fully loosen the germ, by means of a machine with blunt steel arms making from 1,500 to 2,000 revolutions per minute; the excess of starch liquor is then removed by wringers, technically known as "slop machines." Separators are then used to make the necessary separation, and "shakers" are next used for removing the germs from the starch by washing with water. The material is then revolved in a steam-heated drier with a suction fan, then ground in a roller shell mill. It is next fed into a steam heater or cooker, and from this into another, when a jet of steam plays on it as it is moved about by the agitators, in order to supply the moisture required. The heated meal is formed into cakes, slipped between the plates of a regular oil press, and subjected to a hydraulic pressure of 4,000 pounds to the square inch, to remove 90 per cent. of the oil. The starch is subjected to various other operations, and that containing about 10 per cent. of moisture is powdered either by rolls or beaters and then passed through silk bolting machines.

Strength of Starch.—Taking the strength of pure, dry rice starch as 100, maize starch is represented by 87; cornstarch, 85; rye starch, 81; buckwheat starch, 81; oat starch, acorn and wheat starch, 80; barley starch, 78; Bermuda arrow root, 75; pure potato starch, 68; potato farina, 65.

Starch gloss is made of $2\frac{1}{2}$ ounces each of borax, gum Arabic, spermaceti; $6\frac{3}{4}$ ounces of glycerine, and a quart of distilled water or a little over.

Laundry Starch.—Laundry starch is made of potato starch, a trifle of loaf sugar and dextrine, some indigo and a little paraffine. Liquid gloss starch is made of a saturated solution of borax 2 parts and 1 pint mucilage. A tablespoonful mixed in a pint of starch is sufficient.

A teaspoonful of Epsom salts dissolved by boiling improves starch.

A little gum Arabic or pure white wax added to the boiled starch affords a fine gloss.

Potato starch can be easily made in the household by rasping the potatoes on a piece of sheet iron punctured with holes, and throwing the pulp on a fine cloth and washing the starch through a stream of water. The yield of commercial starch varies from 10 to 16 per cent. of the weight of the potatoes.

The production of cornstarch in the United States in 1900 amounted to 247,051,744 pounds; wheat starch, 16,064,569 pounds; potato starch, 33,941,826 pounds; root starch, 745,000 pounds; by-products as a cattle food, 68,745,819 pounds.

Comparative Summary of the Starch Industry.

	1880	1890	1900
Number of establishments ..	139	80	124
Capital invested	$5,328,256	$4,929,155	$11,671,567
Wage-earners	3,119	2,903	2.655
Wages paid	$919,197	$959,108	$1,099,696
Value of products...........	$7,477,742	$8,934,517	$9,232,984

Stationery.

Early Stationers.—The manufacture of stationery has become an important one within thirty years. The old English copyists and text-writers were known as stationers. They organized a strong guild in 1403, and in 1557 received a charter. The manufacture of writing-paper for all manner of correspondence became an important branch of the industry about fifty years ago, and large plants, some located in Massachusetts and others in the Western States, engaged in the production of writings. A combination has been effected of the more important plants in the United States, under the name of the American

Writing Paper Company. The mechanical processes lately employed are of the highest type, and the qualities of paper have been greatly improved by reason of the better facilities.

Variety of Stationery Supplies.—The commercial requirements of the hour have led to the establishment of many industries for the purpose of supplying office and commercial requirements with some three hundred varieties of articles and products as accessories of office necessities, such as ink, paper, pens, furniture and an almost endless variety of conveniences.

Statistics.—There are 139 stationery manufacturing establishments in the United States, employing 3,032 workmen, earning annually about $1,000,000, representing an invested capital in 1900 of $4,494,507, and producing yearly goods worth over $5,000,000.

Steam Engine, Evolution of the.

First Steam Engine.—The nobility of past civilization rested on the sword and its bloody achievements; the nobility of the twentieth century rests upon the control of steam and electricity. Standards have changed, new ideals have arisen, inviting fields have opened to enterprise and are opening; the world is rapidly converting its past into a scrap pile excepting as to the glorious memories of herculean achievements. When Thomas Savery, in 1693, completed the first commercially successful steam engine he placed before mankind a crude instrumentality, which pointed to the triumphs in mechanism and industry that have since marked the world's progress.

What the Steam Engine Has Done.—The steam engine of to-day represents over two centuries of thought, study, experiment and inventive and constructive skill. The galaxy of famous names connected with the construction of the steam engine would fill pages. The specification of patents obtained on it would fill volumes. The books written upon it would make an immense library. The results accomplished by the steam engine are reflected in the civilization and material and intellectual progress of the world. It has helped to create a world's brotherhood and to make possible the opening up of continents that no other agency could open up. It has to its credit a vast, accumulated production of forces, influences, tendencies, capacities and facilities, through which the latent energies of civilized mankind have been poured, in the accomplishment of work that but for it would have remained in the bosom of possibility.

Types of Steam Engines.—A mere enumeration of types of engines would exhibit the versatility of invention. There are the condensing and non-condensing, simple, compound and cross-compound, triple and quadruple expansion, high speed, low speed, vertical, horizontal, locomotive, stationary, marine, besides many other classes. A fundamental feature of the steam engine is its reciprocating parts.

The Corliss Engine.—The Corliss gear was a pronounced innovation in having a separate admission valve and a separate exhaust valve for each end of the cylinder. These exhaust valves are opened and closed by the motion of the rods or cranks connected to them. The advantages of the gear are, the great range through which the cut-off can be varied and the quick action which reduces wire drawing.

Condensers are of two types, surface and jet, where steam is condensed and a partial vacuum formed. The surface condenser is used in marine practice. The cooling towers reduce the temperature of the water from the condenser 30 to 50 degrees, allowing sufficient vacuum. The fly-wheel carries the piston over the dead points and the governor adjusts the power of the engine to any large variation of the resistance. There are a variety of governors, and among those well known are the Porter governor, the Spring governor, Buckeye engine governor and Straight-line engine governor, each of which possesses special mechanical features.

How to Lubricate.—To overcome the friction of parts as much as possible lubricants are used. Lubricants must be of a certain fluidity, must not gum or dry, must not be easily decomposed, must not take fire easily and must contain no acid. Mineral oils are used for valves and pistons, such as graphite, metalline, soapstone and fibre graphite. In some high-speed engines the moving parts are enclosed and the crank runs in a bath of oil. The subject of lubrication is one of the most important with which the engineer and mechanic has to deal.

Reciprocating and Rotary Engines.—The rotary engine of Bianca in 1629 was displaced by Watts' reciprocating engine in 1705. But one important thermo-dynamic improvement has been made since, viz.: the compound expansion. The essential difference between the reciprocating and the rotary engine is in reciprocation—the expansion produces a force which presses on the piston;

in the rotary the expansion produces velocity in a jet of steam. The turbine is usually supplied by steam from 4 nozzles. This highly valuable machine has been improved in recent years to a remarkable degree and is employed in large manufacturing establishments more freely than formerly. Its use on ocean steamships is also receiving the enthusiastic attention of naval engineers who anticipate some radical changes in ocean steamships through its adaptation to ocean service.

Laws of Steam Expansion.—The theoretical efficiency of the steam engine is decreased by several causes, among them condensation, reëvaporation and friction of parts; a partial remedy is found in jacketing, which branch of mechanical engineering has been much improved by the use of better material and greater skill in its application. The superheating of steam utilizes a part of the heat in the waste gases and is efficient if low pressure is used. Tests show a very decided gain in economy from using superheated steam, yet practically no permanent results have been obtained on account of the cost of maintaining the superheating apparatus. Compounding is the most effective method of increasing the number of expansions and at the same time avoiding excessive cylinder condensation. For simple condensing engines there is no economy in raising the steam pressure above 80 pounds, while in compounding, the pressure can be advantageously raised. The gain due to high pressure and the greater number of expansions and compounding may be 20 to 30 per cent. or more. The gain from using a triple over a compound may be from 5 to 10 per cent. or even more.

Steam Consumption and Horse-Power.—The best point for cut-off for a simple engine, jacketed or not, is about one-third stroke for non-condensing, one-sixth stroke if condensing; shortening the cut-off causes loss of both thermal and mechanical efficiency. The two factors, valve motion and clearance, limit our increase of speed beyond a certain point, just as condensation limits the indefinite increase of boiler pressure. The following represents the average steam consumption in pounds per indicated horse-power for various types of engines:

Triple expansion, stationary, 11 to 14 pounds; triple expansion, marine, 13 to 16 pounds; compound stationary, 12 to 15 pounds; compound marine, 18 to 21 pounds; simple condensing, 17 to 20 with jackets; simple condensing, 18½ to 22 without jacket; simple non-condensing, 24 to 33 or more.

Steam Indicators.—The indicator plays a very important part in the working of a steam engine. James Watt was the first to see the need of accurate knowledge of the action of steam in a cylinder. He invented the indicator. It had no lateral motion, therefore all it showed was the pressure of steam in the cylinder and the perfection of the vacuum. The diagram or cards is the result of two motions; the horizontal corresponds to the movement of the piston, and the vertical movement of the pencil is in exact ratio to the pressure of the steam in the cylinder. The later improvements have made the indicator light, compact, durable, and accurate. The Thompson indicator consists of a cylinder, in which the piston is fitted, a spring, multiplying lever and parallel motion for a pencil, and a cylinder or drum for the paper. In the Crosby indicator the piston is formed with shallow channels on its outer surface to retail oil, and the socket in the center is supported by a central web, and projects upward and downward. The Tabor indicator is used extensively in the navy. Its chief peculiarity is the means employed to obtain a straight-line movement of the pencil. Inside the steam cylinder is a lining in which the piston moves.

Purpose of the Indicator.—The purpose of the indicator is to find the indicated horse-power. By comparison of the indicated horse-power with the brake horse-power the mechanical efficiency is obtained. It also shows the time and manner of the four events of the stroke, viz.: the admission, cut-off, release and compression. Work is equal to pressure multiplied by the number of strokes per minute. The pressure is the average net pressure acting on the piston during the stroke, and is called the mean effective pressure.

Rules of Efficiency.—Tables for determining thermal efficiency have been elaborately worked out, and with which any intelligent mechanic can readily familiarize himself and know what his engine is able to do. It is found by ascertaining the difference between the absolute temperature of the heat and the absolute temperature of the heat rejected by the engine, and dividing this by the proper numeral indicated in the thermal tables which apply to the prescribed conditions. These tables are worked out for all conditions and are readily applicable.

Valve-Gears. — The study of valve-gears has brought out quite a variety of devices for controlling the passage of steam at various points

In most engines the valves receive motion from one or more eccentrics. The simplest valve is of the plain slide type with one eccentric. This valve both admits and exhausts steam, and is generally moved by means of an eccentric which is fastened to the shaft of the engine. A valve is said to have "lead" when it begins to uncover the steam port before the piston is at the end of the stroke or the port is slightly open when the piston is at the end of the stroke. The amount of lead is the distance between the edge of the valve and that edge of the steam port from which it is traveling. Valves are given outside and inside "lap" in order to use steam expansively. The outside lap influences cut-off and expansion, and inside lap controls release and expansion. The outside lap is often called the steam lap and the inside lap the exhaust lap.

Principle of the Valve-Gear.—Various diagrams have been designed to show graphically the events of the stroke for given lap lead, angular advance, etc. The Zeuner diagrams are probably the best and most used. All the problems on valve-gears involve relations between certain variable quantities, viz.: the valve travel, the angle of advance and the angle of lead, the inside and outside laps of the valve, and to the points of the stroke at which admission, cut-off, release and compression take place.

Steam-Pipe Proportions.—The proper area of steam-pipe is the subject of careful calculations, which are set forth in tables arranged for convenient reference and instant use by engineers and mechanics. These tables record the results of long experience and are of great value in determining proper steam-pipe proportions. The pipes, if long, should not permit the mean velocity of steam to exceed 100 feet per second. The steam ports are made large enough to allow a free exhaust with a minimum of back pressure. Experiments show that the allowable velocity of steam through the ports may be 6,000 feet per minute.

Changes in Gear.—The lead of the ordinary stationary engines varies from zero to three-eighths of an inch, one-sixteenth being an average. The amount of lead is not determined by rule, but by experiment. Valves are usually set cold and later on adjusted from indicator cards. One of the earliest arrangements for reversing engines and changing the ratio of expansion was the Stephenson link motion. The Gooch link is stationary. In the Allen link the link is straight, as the change of gear is effected partly by shifting the link and partly removing the block. This gear combines the most important features of both the Stephenson and the Gooch links, but it is falling into disuse as the curved links can be very easily made.

Valve Action.—One of the common methods for driving valves without using eccentrics is the Joy valve-gear, which can be used on all types of engines, but is especially adapted for locomotive and marine work. The piston valve is used where high steam pressure causes a large amount of friction between the valve and its seat. It is formed by the revolution of the section of a plain slide valve about an axis. Its action is the same as that of a slide valve. The slow opening of the plain slide valve is remedied by the "trick valve," so made that a double volume of steam enters during admission. Valves in most engines are so firmly held that there is excessive friction, which calls for heavy and strong valve-gear. Numerous methods have been devised for partly relieving this pressure, one of them being a bronze ring or cylinder fastened to the back of the valve.

The Expansion Valve.—Meyer's expansion valve is a simple device which moves on the back of the ordinary valve and regulates the point of cut-off, to reduce the disadvantages of the plain slide valve and link motion. It is usually considered that engines having the Corliss gear cannot run at a greater speed than about 125 revolutions per minute.

A mere reference to some of the essential features of this most mighty instrumentality of modern civilization is much like referring to the rays of the sun to account for the sun. The steam engine has enabled man to develop and apply human capacities that would forever have remained dormant. While with it much has been accomplished, its present achievements are but as the letters of the alphabet of mankind's progress.

Street Car System, The.

Influence of the New Mode of Travel.—The American street-car system has developed to its present limits within less than fifty years. It is a most important innovation in urban convenience. The facilities afforded for travel by this means have wrought changes which could not have been foreseen. Besides having made it possible for persons to live at relatively remote distances from business centers, the influence of this system has brought about an appreciation in values of suburban properties otherwise useless, excepting for semi-agricultural requirements. It also has stimulated the growth of cities and towns and has enabled population to spread over larger areas, and has laid a broader foundation for the great building industry which enables vast numbers of people to live comfortably in cities and to come and go with the least possible loss of time. The development of the system has given rise to a number of industries in the manufacture of equipment and appliances for the operation of street-car lines.

The Electrical Current.—The transforming feature occurred in the application of electricity to the propulsion of cars, by which greater speed was secured, with less interruption to travel. Electricity on traction lines is now almost universal, and a number of important improvements have been introduced in the application of the electric current, by which greater efficiency is secured and trolley lines are enabled to develop greater capacity to handle traffic.

Stage Coach to Trolley.—The transition from the stage coach to the horse car, and from the horse car to the cable car, and from the cable car to the overhead trolley as well as the underground trolley, marks the rapid strides from primitive methods of travel to the present admirable system. Street-car trucks consist of a rigid frame independent of the car body and adapted to support the car motor with fine mathematical exactness. Some street-car trusses are of the bogie type, which is also adapted to support the motor. Metallic car trucks made of common rolled-steel sections or of pressed steel, or of pressed-steel sheet plates, are in moderate use and are found to answer the requirements.

Construction.—For suburban electric railway service the long car body with a swivel truck under each end is in favor. There are improvements in motor trucks with spring-supported equalizer bars on either side, which are meeting with liberal acceptance. Elliptic springs are preferable to coil springs where abruptness of action is to be avoided. Coil springs, however, are cheaper of equal capacity. Various improvements have been made in friction attachments to a coil spring to dampen its effect so as to approximate the action of an elliptic spring. Devices for heating cars are in common use, and which supplanted stoves, to the great comfort of patrons. Cars are built in various sizes and styles, some known as summer or open cars, with seats placed horizontally or longitudinally, and in the former the backs of the seats are made to turn, thus saving the trouble of turning the car.

Trolley methods have also been adapted for the transportation of excavated materials, such as earth, coal or ore, by overhead cables.

Signal Systems.—A signal system has been introduced, both lightning and "fool-proof," which is a very fortunate provision, especially in the latter regard. By it signals are visible day and night; under it, burned-out lamps do not make the system inoperative. When the car enters a block, one green signal at each end is aglow. Signals show the direction in which the car is moving, and red lights show along the track in both directions. Any number of cars can pass through a block together under this system. The first car in, sets signals to danger; the last car out sets them to safety. Cars trying to take blocks at opposite ends hold each other up; backing out of block does not derange signals. There are no operating magnets in series and no operating magnets and mechanism in circuit with overhead wires, thus securing freedom from lightning. Contact-makers 12 inches long are certain of action, and operate at a speed of 60 miles an hour.

Future of the Trolley System.—The extension of the trolley system from town to town and city to city throughout the United States promises, in a comparatively short time, has furnished a vast network of trolley intercommunication which will greatly influence travel and effect the well-being of the people in many directions. Trolley-line construction is presenting considerable competitive opposition to the standard railway lines, and many railway managers find themselves obliged to become advocates of trolley lines, and in some instances to take steps to protect themselves from trolley-line competition by better service, involving more frequent train facilities, more frequent stoppings, and in general, in the adaptation of their facilities to the petty traveling requirements of the communities which they serve.

Trolley Capital.—Trolley-road capital is mounting into hundreds of millions of dollars, and it is quite safe to say that the system, when practically completed as to construction, will serve the people, as to personal transportation at least, even more thoroughly than the great railway systems of the country. While the trolley line is only available for short rides, the percentage of patrons who travel comparatively long distances will naturally increase.

The commercial necessities of the greater manufacturing and commercial interests call for quick travel between the greater cities, but there is a tenfold greater traveling necessity arising out of the needs of the masses of the people, who will readily avail themselves of the trolley system for travel within the more limited areas which their daily convenience demands.

Sugar Making.

Where Sugar Came From.—The introduction of sugar into Europe has been credited to the Saracens, who transported it into Spain and some of the islands of the Mediterranean Sea from far-off India in the ninth century. The Crusaders in the twelfth century found it in Syria; the Spaniards and the Portuguese carried it to the Canary and the Madeira Islands in the fifteenth century, and later on the Spanish navigators carried it to the West Indies, where its cultivation and manufacture assumed the dimensions of an industry, from whence supplies were shipped to Europe.

Sugar Cane.—Sugar cane was once a wild plant, but subsequently became the subject of cultivation in India, China and the South Sea Islands. Sugar was readily extracted from sugar cane by more or less primitive methods and which stimulated its early cultivation. The production of sugar from beet root has latterly become an important industry.

Beet Sugar.—Much enterprise is manifested in the development of the beet-sugar industry. The first experiments were made in 1830, but its production did not assume commercial importance until 1863. The first extensive factory was erected in California in 1870. Claus Spreckels, at Watsonville, Cal., showed the possibilities of the industry. Up to the year 1904 over forty factories had been built, with a nominal daily capacity of 25,000 tons of beets and an annual capacity of 250,000 tons of sugar.

In 1900 there were 31 establishments, with a capital of $20,958,519, wherein were produced sugar worth $7,323,857; about half of this production was made in California. Michigan comes second, producing about one-half as much as California.

Beet Juice.—The first step is the expression of beet juice, which is preferably done near the centers of cultivation. Pipe lines are built in some localities to pipe the juice to the central factory.

"Crystallization in Movement."—The "crystallization in movement" process consists in agitating the material, or "massecute," during crystallization, which keeps the crystals in motion and reduces the time required for crystallization to four or five days instead of several weeks, as formerly. The apparatus consists of a large wrought-iron cylinder fitted with a water jacket and agitators, and has a capacity of 35 tons of massecute of low products only. This material is gradually cooled during the progress of crystallization, thus forcing the sugar out of solution.

Carbonitation.—The use of carbonic acid gas is an essential feature in sugar making. The process is known as carbonitation. This takes place after the separation of the sugar juice from its impurities, which process is termed deprecation. This separated product is saturated with carbonic acid gas. The carbonitation process is conducted in tanks 18 to 20 feet deep, in which cottonseed oil is used to prevent foaming.

Filtering.—The juices and liquors are repeatedly filtered to purify the juice for the subsequent chemical action. At first filter pockets were used, but these gave way to mechanical filters in which the joints and fastenings have been the subject of improvement.

Sulphurizing Juice.—In many factories the juice is treated with sulphurous acid in tanks similar to those used in carbonitation. In others a continuous apparatus of wood is built. White granulated sugar is manufactured without the use of bone black, sulfurous acid being sufficient.

Evaporation.—The Welner-Telwick type is used for evaporating the juice, in which horizontal tubes of small diameter are employed with quadruple and quintuple effect.

To enable the managers to make a quick estimate of the density of the massecute in the vacuum pan an instrument is attached to it called a brasmoscope, which reveals temperature and pressure. By its use the material may be concentrated to uniform density.

Centrifugals for Drying. — The water-driven centrifugal for drying sugar is a recent improvement, which does away with belting and shafting, in which each machine is independent of all others.

Molasses Processes. — Two molasses processes are in use, known as the Steffen, which is a saccharate process employing quicklime to precipitate the sugar, and the Osmose process. In the lead saccharate process the molasses is mixed with caustic potash and lead carbonate, forming a saccharate of lead which is washed into a filter press, suspended in water and decomposed with carbonic acid, thus liberating pure sugar. The difference between sugar and molasses is that sugar comes through crystallization; molasses without it. The Osmose process is not much used.

The Polariscope.—The commercial value of beets determines the prices paid for them. The polariscope renders it possible to make a large number of tests with great accuracy and little labor. The recent invention of a pair of prisms which give a triple instead of a double field, enables a prompt and accurate adjustment to the neutral point to be made.

Comparative Summary of the Sugar and Molasses (Beet) Industry

	1880	1890	1900
Number of establishments	4	....	30
Capital invested	....	....	$20,,141,719
Wage-earners	....	1,970	1,970
Wages paid	$62,271	....	$1,092,207
Value of products	$282,752	....	$7,223,857

Sugar and Molasses Refining.

	1880	1890	1900
Number of establishments	49	393	832
Capital invested	$27,432,500	$24,013,008	$184,245,519
Wage-earners	....	7,043	14,262
Wages paid	$2,875,032	$2,385,654	$6,945,811
Value of products	$155,484,915	$123,118,259	$240,969,905

Surgical Instruments and Appliances.

Science of Surgery.—The practice of surgery is both a science and an art. Surgery was practiced by the Egyptians 400 to 500 years before the Christian era, and surgical instruments were then in common use. The Arabians made remarkable progress in the art, devising instruments of now recognized value. The founder of modern surgery is credited to Andrew Vesalius, who was born 1514, and who published a work in 1543 which showed remarkable acumen, broad knowledge and thorough experience. Subsequent surgeons, among them Ambrose Pare and John Hunter, still further broadened the field of surgery. In the latter days ether was employed and chloroform later on, in surgical operations. Antiseptic treatments followed and the system of inoculation introduced by Pasteur still broadened this great field. The introduction of lithotrity, the cure of aneurism by pressure, the use of the ophthalmoscope, laryngoscope and other instruments enabled the surgeon to accomplish results which were not before within his reach. Among the more recent triumphs of surgical art, due in no small degree to the introduction of surgical instruments, are operations for appendicitis and brain tumor.

X-Ray in Surgery.—Still later the discovery of the X-ray has vastly broadened the field of surgery by enabling the surgeon to see through the human body and ascertain abnormalities and thereby know how to act. Surgeons are now endeavoring to obtain equally as valuable results without the aid of the X-ray. M. Guilloz, a French physicist, caused the tube producing the rays to oscillate by means of a cam revolving 300 times a minute. The cam is so cut that the time taken in revolving it from one position of rest to the other is about one-tenth of the period of revolution. Two radiographic images of the same object as seen from different points are thus formed on the viewing screen, and by means of shutters electro-magnetically controlled by the oscillating apparatus, the right eye sees one image and the left eye the other, vision being cut off while the tube is changing its position. The result is that the combined image stands out like a solid reproduction of the object within the human body which it is sought to remove.

Liquid Air.—The first process of production is to compress common air eight hundred times; *i. e.*, eight hundred cubic feet into the space of one foot in a strong tube. The contents of the tube are then tapped into a larger one, which surrounds the first. The process of tapping and exchanging from one tube to the other cools the condensed air, till, by and by, a temperature of 312 degrees below zero is reached, when the air becomes liquid. In this condition it is an aid in surgery, as a spray of it deadens diseased parts quite as effectually as cocaine.

Radium.—Radium, the newly-discovered radioactive substance extracted from pitch-blende ore, is looked upon as a highly effective agent in the cure of cancerous affections. Though as yet too costly for general experimental purposes, much is hoped for it in the domain of medicine and surgery.

Comparative Summary of Surgical Appliance Industry.

	1880	1890	1900
Number of establishments	71	155	219
Capital invested	$843,142	$856,396	$2,487,494
Wage-earners	477	6121	1,539
Wages paid	$265,372	$300,804	$620,801
Value of product	$906,303	$1,650,033	$3,932,358

Tanners and Tanning.

Use of Leather.—Leather comes next to fibres in importance to mankind in comfort, convenience and utility. Its more important uses are in boots and shoes, harness and saddlery, belting, satchels, gloves, etc. The sources of supply which began, perhaps, with the sheep, have steadily increased until there is scarcely an animal of considerable size but what feels, if he were able to reflect on the subject, that his hide is an unacquired asset of the leather industry. All quarters of the globe, including the waters of the Arctic seas, are sought to furnish animals for their skins, regardless of the willingness of their possessors to part with them.

Tanning.—Passing over a long and entertaining history from the earliest times concerning the use of leather and coming to our own times, we find that tanning, like dyeing and weaving, constituted one of the many early household employments of the colonists, and the "cobbling" bench was an indispensable adjunct when outdoor employments were out of season. The necessity of a specialization of this industry existed long before the want was supplied. As early as 1790, Colonel William Edwards, of New Hampshire, manufactured leather on an extensive scale, and he supplied many small shops throughout the New England States with stock. He established large tanneries and improved many processes and stimulated the erection of many "bark mills," which, by 1823, numbered 193, besides 304 tanneries in that State.

First Colonial Tannery.—The first tannery in the colonies was operated in Virginia in 1630; soon after a tannery was established in the village of Lynn, Mass. Very soon the industry of manufacturing sumac, sumac bark, prepared sumac and ground sumac arose. These were followed by ground bark, hemlock bark extract, dyeing and tanning extract, and chip wood.

The First Company.—The first incorporated company to conduct leather manufacturing on a large scale was established in 1825 in New Hampshire, and its success stimulated the formation of other companies elsewhere, all of which appear to have prospered, when a supply of bark was available at low cost. The abundant supply of bark in Maine stimulated the tanning industry there and as early as 1810 there were 200 successful tanneries which averaged an annual output of 275 hides each. In those days, home-slaughtered hides were tanned and the peripatetic shoemaker made his annual rounds among the farmers and residents, making shoes for each family.

Tannin.—The sources of tannin in nature are very numerous, over 350 different vegetables being enumerated as producing it. Mineral salts have also been employed for the same purpose and more recently electric current and organic compounds, such as formaldehyde, have been employed to convert hides or skins into leather. Gall nuts are the richest in tannic contents of any vegetable source. The usual sources of tanning materials are oak and hemlock barks, oak wood, sumac leaves, and the palmetto root. Oak and hemlock naturally come first, as they contain sugars, gum and resins, and coloring matters as well as tanning.

Sumac.—Sumac comes next in importance, its tanning properties residing in the leaves. When cured the sumac is ground in mills under heavy wooden wheels and enclosed in a tight covering to prevent the escape of the dust which arises abundantly.

Palmetto Root.—This root, found abundantly from Florida to Louisiana and in Tennessee, shows 10 per cent. of tannin, which produces tough grain and strong durable leather. It tans rapidly, gives a pleasing light color, toughness and pliability and is a good filler of leather.

Tanning Extracts.—The advantages of extracts are that they are under perfect control and do away with the storing of large quantities of bark. A barrel of extract is equal to a cord of bark. Tanning extracts in common use in the United States are made from chestnut, oak bark, oak wood, hemlock bark, canaigre and sumac. Black oak-bark extract gives bloom to leather. Coloring and dyeing extracts are also made from logwood, fustic and other materials.

Hemlock Extract.—Various methods prevail for the preparation of hemlock extract. No chemicals whatever are used in the extract as made in Pennsylvania. The bark is not crushed or pressed to get a larger, and therefore somewhat impure, yield.

Manufacture of Tanning Extracts.—The manufacture of tanning extracts closely resembles the process for extracting sugar. Most manufacturers decolorize the liquid before concentration by the addition of some metallic salt or albumen and bisulphide of soda.

Chrome Solution.—The use of chromium compounds was discovered by a German chemist, but the tannage could not be made permanent. The remedy for this defect was applied in Philadelphia, through a patent in 1888, granted to William Zahn, by the use of hyposulphide of soda, which has resulted in the building up in that city of the largest and best equipped leather factory in the world, whose product is known as "Vici" kid.

Vici Kid.—The skin is first dipped in a solution of chronium salt acidified by hydrochloric acid, and is subsequently dipped in a solution of bisulphite acidified with hydrochloric or sulphuric acid. Any equivalent chromium salts may be used.

Electricity in Tanning.—Electricity is used in the tanning of hides and skins, and many processes have been invented. Some of them employ tannin solutions, but most of them refer to the use of mineral tannage with chromium, aluminum, tin and other metallic salts on light skins, such as calf, goat and sheep. One of the best known processes for rapid tannage by electricity is known as the Growth system, which is threatening bark methods of tanning. Extracts and chrome methods are taking their place, and the chemist has become an invaluable agent in this development.

Improved Chemical Process.—An event in the tanning and leather industry was the improved chemical processes, which were greatly developed in Philadelphia between 1856 and 1860. That city early became one of the leading leather and morocco manufacturing centers, largely because of its control of improved processes and an abundant and cheap supply of hemlock bark. The industry was chiefly carried on in that city and in Tioga, Potter, Elk and Clearfield counties, in the center of the forest belt. The output of leather products was especially large in Philadelphia, York and Lancaster counties, and tanneries sprang up all over Pennsylvania. The industry soon extended into many other States where supplies of bark were available, and it is now in a prosperous condition. In 1900, 254 establishments in Pennsylvania produced leather valued at $55,615,000.

Tanning in New Jersey.—New Jersey gained much prominence in leather and morocco manufacturing, and when the processes of "patent" and "enameled" leathers were introduced it rapidly took the first place. Newark became the center of this industry. A small tannery was erected there in 1770. By 1792, three were in successful operation. The business grew in various parts of the State and boot and shoe manufacturers throughout a large section of the country were supplied from the "Jersey tanneries." During the decade between 1860 and 1870 the leather industries in Newark practically monopolized the business. The displays by Newark manufacturers at the Centennial Exposition at Philadelphia resulted in a material expansion of demand.

During the past decade the number of establishments in that State engaged in tanning, currying and finishing leather increased from 31 to 77, and the value of products increased fourfold.

Tanning in Michigan.—Michigan, because of its nearness to raw material, has made remarkable strides, the increase in the past decade being 245 per cent. This growth was due to the fact that the hides were transported from centers like Chicago to the places where the tanning was done, instead of carrying the tanning products to the hides. The industry is obliged to shift from time to time to follow the forests as well as to keep within easy reach of markets. That the tanning industry is no respecter of localities is observable in the fact that the industry in Tennessee increased 121 per cent. during the past decade and is now forging ahead.

Kinds of Leather.—The manufacture of morocco leather has become a very important feature of the industry. The usual commercial classifications in the United States are imitation French kid, glazed kid, pebbles, straight-grained goat and oiled goat and patent and enameled leathers. These leathers were evolved from the gradual improvement of Cordovan leather, which is soft, small-grained, colored leather, and derives its name from the Spanish city of Cordova. Saffian leather, another name for morocco, is produced from goatskins and derives its name from Saffi or Asfee. Another leather made there is Mozador. Large quantities of goatskin are imported from European countries and from Mexico and other countries. In fact, commercial requirements are constantly seeking new sources.

Leather Centers.—Among the leading centers of morocco leather manufacturers may be mentioned Newark, N. J.; Philadelphia, Pa.; Wilmington, Del., and Lynn, Mass. The finer grades are manufactured from goatskins and inferior grades from sheepskins and split calfskins.

Hides.—South America supplies large quantities of hides for coarser uses. The Western section of the United States also furnishes considerable quantities, but the westward spread of population is gradually restricting the area available for the raising of cattle.

The following is a Comparative Summary of the Tanned, Curried and Finished Leather Industry in the United States.

	1880	1890	1900
Number of establishments...	5,628	1,787	1,306
Capital invested............	$73,383,911	$98,088,698	$173,977,421
Wage-earners..............	40,282	42,392	52,109
Wages paid....	$16,503,828	$21,249,989	$22,591,091
Value of product	$200,264,944	$172,136,092	$204,038,127

A Comparative Summary of the Entire Leather Industry in the United States.

	1880	1890	1900
Number of establishments...	32,327	33,970	40,751
Capital invested............	$152,380,350	$265,687,684	$356,581,838
Wage-earners................	207,906	233,496	251,920
Wages paid..................	$79,747,644	$107,978,195	$105,571,004
Value of product...........	$461,189,543	$529,311,299	$615,311,269

Taxidermic Art.

The Art.—Taxidermy is the art of preparing and preserving the skins of animals, and also stuffing and mounting them so as to cause them to resemble the living form as nearly as possible.

Skill Required.—Though taxidermy has not developed to the dignity or extent of an industry it engages the attention and skill, and, in fact, the enthusiasm of quite a number of patient, industrious and artistic workmen who find pleasure and profit in the stuffing of skins of various animals and birds to maintain them in life form. The skill of taxidermists is more frequently met with in museums than elsewhere, but finely finished specimens are frequently found in private collections. The skin is subjected to a number of delicate processes known only to the taxidermists and it is maintained for an indefinite period in the state in which their skill leaves it.

Development.—Some of the secrets of mummy preservation have been transplanted into taxidermy, at least so far as the preservation of skin is concerned. The examination of the skin under a microscope after many years reveals a permanency of arrangement of the original fibre where it can be seen. The art has been developed to a very high state of perfection, more particularly in Europe, but to no inconsiderable degree in the United States. Of late years it has been receiving more attention because of the increasing demand for various animals which it is desired to preserve in life-like forms.

Comparative Summary of the Taxidermy Industry.

	1880	1890	1900
Number of establishments..	16	63	147
Capital invested	$25,750	$293,112	$366,077
Wage-earners................	150	90	180
Wages paid..................	$22,000	$46,000	$91,140
Value of products	$82,500	$231,773	$513,112

Telephone Mechanism and System.

Early History.—On July 20, 1820, Oerstead, a professor in the University of Copenhagen, discovered that a magnetic needle tends to place itself at right angles to a wire carrying a current of electricity. Arago and Davy, in 1825, discovered magnetic properties, and in 1825 William Sturgeon made the electro-magnet as we know it to-day. Joseph Henry and Faraday, in 1831, discovered the converse of the law discovered by these earlier discoverers. In 1837 Professor Page, of Salem, Mass., discovered that a rod of iron suddenly magnetized, or demagnetized, emitted sound. A year or two later Professor Morse sent signals on a strip of paper. In 1854 Charles Boursenl predicted the transmission of sound and but for one little error would have accomplished its transmission. In 1861 Philip Reis constructed a telephone that readily transmitted musical notes and, in a degree, speech. In 1876 Professors Bell and Gray simultaneously invented telephones. Bell's transmitter was used as a generator of the current. Gray devised a transmitter which caused a variation in the strength of the current independently generated.

The Telephone Transmitter. — The secret of transmitting speech by telephone consists in causing an undulatory or alternating current to flow in the circuit over which the transmission is to be effected. The strength of the current has at all times to be in exact accordance with the vibratory movements of the body producing the sound. Bell's and Gray's transmitters caused variations in the resistance of the current.

Berliner devised a transmitter in 1877. Edison followed, and Hughes, still later, demonstrated that a loose contact between electrodes is preferable to a strong contact. Hummings, in 1881, devised a transmitter in which he used a mass of finely-divided carbon granules between two conducting plates.

Telephone Receivers.—A large number of the telephone receivers are of the single pole type, but they are being superseded by the bi-polar type, which strengthens the field in which the diaphragm vibrates, presenting both magnet poles to the diaphragm. The transmitter of the Western Telephone Construction Company is at present probably the simplest manufactured. In granular carbon transmitters trouble is experienced from packing, due to the granules settling in compact mass by constant agitation.

Carbon Transmitters.—Much effort has been made to discover a substitute for carbon, but it produces change in resistance with changes in surface contact, all things considered, better than any known surface. Blake's transmitter is still largely used. Crossley's belongs to the "multiple electrode" type. Many inventions followed. Payne's and Gharky's are among the more recent, which produce actual alterations in the current flowing in the primary and which act on the principle of a pole-changing switch. The Jacques granular carbon transmitter uses a twenty-volt current, which maintains the granules in a sensitive condition to sound waves.

Induction Coils. — The use of induction coils allows the changes in the transmitter to bear a much larger ratio to the total resistance of the circuit in which these changes occur. In primary batteries the Le Clanch cell is used largely. The Bell in long-distance work only uses a cell known as the Standard Fuller. In this, the positive electrode is a heavy block of zinc molded into conical form around a heavy copper wire which forms the negative pole. The gravity battery is used where a small constant current is flowing. In the Gordon cell the negative element consists of a perforated tin cylinder filled with a powerful depolarizing agent, best adapted for closed circuit work.

Calling Apparatus.—In the magneto-generator apparatus, the old method is practically superseded. Until recently only cast iron was used for pole-pieces, but generators are now made in which soft sheet-iron pole-pieces are stamped and formed into the desired shape. The sine wave has been found to be the most efficient in ringing magneto-bells. The tendency in the present form of ringers is to make a magnetic circuit, which is subjected to the changes due to the magnetizing force as short as possible, and to make the magnetic circuit of the very best possible material. The device for commercial calling and the hook switch have been brought to a high state of completeness.

The Telephone Relay or Repeater. — A great many improvements have been made in the mechanical construction of relays, but they embody only the combination of an ordinary transmitter with an ordinary receiver. The Erdman relay does away with mechanical connection and uses a current of air or gas. The Stone relay has all its working parts enclosed in a vacuum, and messages are transferred automatically, it is said, with a well-defined gain in volume or loudness.

Self-Induction and Capacity.—The phenomenon of induction between the various parts of a single coil of wire, each on the other, is termed self-induction. Telephonic currents are very complex and are composed of a fundamental tone and overtones, which by various blendings produce speech. The following table gives the specific inductive capacities of some of the more important insulators:

Air	100	Ebonite	2.284
Glass	3013	India rubber	2.240
Shellac	2740	Paraffine	1.994
Sulphur	2589	Carbonic Acid	1.00036
Gutta-percha	2462	Hydrogen	0.99967
		Vacuum	0.99941

Switchboards.—Switchboards are of two kinds —manual and automatic. In the manual switchboard, each line terminates in the spring-jacks, which are sockets containing or associated with simple switching devices. Plugs are inserted into the jacks to make a connection with any line. Metallic circuits are rapidly superseding ground circuits in order to avoid induction. Switchboards in common use for metallic circuit exchanges are built on the same principle as those foregrounded circuits.

The Multiple Switchboard.—It is designed to enable each operator to make any connection required without the aid of any other operator. While the idea underlying the construction of multiple switchboards is simple, in practice the work is complex. The boards are divided in sections. Each line is provided with a single spring-jack on every section of the board. Each section therefore contains a spring-jack for every line entering the exchange and also a number of line drops or rather lights instead of drops. The advantage claimed for this division of the multiple board is the enormous saving of multiple jacks. The limit to the number of subscribers in a single multiple board is found to be about 6,000, a greater number rendering the boards so cumbersome that an operator cannot reach all of the multiple jacks on her section. By dividing the exchange into four divisions it becomes possible to place as many as 24,000 subscribers in a single exchange.

Transfer Systems.—Systems depending for their operation upon the transfer of a connection from one connection of a board to another are termed transfer systems. One of these is called the express system, and can successfully handle an exchange having over 6,000 subscribers. One striking feature in it is that no magneto-generators are used at the subscribers' station. All signaling between subscribers and the operators and between the different operators is entirely automatic. What is known as the Cook-Beach system has been in long use in some of the Bell exchanges of medium size. Large switchboards are also operated on this plan.

Common Battery Systems.—It was pointed out in 1890 that it was possible to supply all the cord circuits from a single battery by the bunching together on one side of each of the cord circuits, the battery supplying current in multiple to the various pairs of lines in use at one time. This method has been improved upon by supplying current to the transmitter of the subscribers' station over the two sides of a metallic line circuit in parallel, using the ground as a return. This later method has been improved by an extended series of inventions. The list of protective devices is long and interesting in point of ingenuity displayed by inventors.

Distributing Boards.—The chief purpose of distributing boards is to bring all the confusion among the wires leading from the subscribers to the switchboard into one small space and then to minimize that confusion as much as possible. In modern exchanges the wires from the vertical side of the distributing frame do not pass directly to the switchboard, but to an intermediate distributing frame, the function of which is to permit the rearrangement of the lines upon the switchboard, in order that they may be grouped to the best advantage for quick service.

Party Lines.—Party lines are of two classes—where a code of audible signals is employed to enable subscribers to distinguish their calls from others, and where a system of selective signaling is employed, so that one party can be called up without disturbing others. Selective signaling is divided into three classes. Step by step mechanism has brought out quite a variety of devices. The harmonic systems of selective signaling have not produced any very practical results.

Material.—The wires used in telephonic work are copper and iron. The poles used are Norway pine, chestnut, cedar and cypress.

Statistics.—In 1903 the telephone system of the United States, as represented by the Bell Company, which is the controlling one, embraced 3,150,320 licensed instruments, 1,277,983 stations, 2,443,750 miles of wire. Over 3,000,000,000 messages were exchanged. The capital invested was $114,946,500. The total number of employés was 50,350.

Long-Distance Telephone Lines.—The telephone has done more than any other instrument to facilitate the exchange of intelligence at comparatively short distances, and its value and importance to society is beyond computation. The establishment of long-distance telephone lines is steadily progressing and the limits at which communication can be maintained is not as yet determined. The long-distance lines in California first established the fact that telephonic communication could be conducted over much longer distances than had been previously regarded as possible. Long-distance lines are now being established between all the large cities with commercial success and the problem of trans-atlantic telephony is now engaging the attention of electrical experts and is engaging the consideration of capital. It is too soon to speculate on the outcome of this bold purpose but the world has learned to not question the possibility of apparently impossible purposes.

The telephone system, while not lessening the volume of communication carried on by mail, has virtually increased the exchange of conversation, and its more recent introduction into homes indicates that its field is expanding beyond the dreams of its originators.

Tin and Terne Plate Manufacturers.

What Tin and Terne Plates Are.—Tin or tinned plates are thin sheets of iron or steel dipped in a bath of molten tin. Terne (literally three, i. e., plates of three metals) plates are of the same material dipped in a bath of an alloy of tin and lead, the proportion of tin varying from 10 to 33 per cent. Tin plates are largely used for utensils, terne for roofing and other purposes. Fugitive references are made of the use of tin prior to our era, but its commercial introduction is due to the people of Bohemia, who discovered it about the year 1240, and applied it to the coating of iron sheets, which soon found sale all over Europe.

Cornwall Tin.—About 1670 tin plates began to be produced with Cornwall tin, the method having been copied from Saxony. Prior to 1728, iron plates were unevenly made by hammering; rolls were introduced that year, and the manufacture of tin plates soon after spread rapidly. Being manufactured by machinery, they could be rolled to any desired weight and thickness, and thereby utilized for a variety of purposes.

A Crowning Event.—The introduction of "soft" steel was an important event in the industry, which was begun in 1876, or three years before its use was attempted in Wales, the home of the tin-plate industry. Up until a comparatively recent date the bulk of tin and terne (black) plate was imported from Wales, but American inventive ingenuity and enterprise, aided by favorable tariff duties, developed a productive capacity which now largely excludes the foreign product.

Process of Manufacturing.—Black plates are made from steel billets, rolled into flat bars 6 to 12 inches wide, which are cut into short pieces and reheated and rerolled four times, usually, into certain required sizes. The finished "packs" are trimmed and cut into pieces 14 × 20 inches or 20 × 28 inches.

Pickling Process. — The plates are then "pickled" by immersion in heated diluted sulphuric acid, and washed in clean water, but patented pickling machines are now generally used.

Annealing Process.—This process is conducted in cast or wrought iron "pans" or "stands," and covered with "annealing boxes" filled with sand, to exclude air. They are run into an annealing surface, kept at a red heat until softened, then taken out, cooled and packed.

Cold Rolling.—The plates are passed through cold rolls two or generally three times, the rolls being highly polished, and then subjected to a second annealing.

A Second Pickling.—To prepare the plates for tinning they are treated as before, but in a weaker solution, and protected from reoxidation by immersion in clean water. They are then ready for dipping or tinning.

The Tinning Process.—Two processes are used, the "acid" and the "palm oil." In the latter process, which is not much used, the sheets are successively immersed in three pots containing a mixture of tin and lead. In the "acid" process a thin layer of muriate of zinc floats on a bath of molten tin. The plates are passed through this flux into the tin, and emerge farther on, when the surface is covered with oil. Rolls are used to pass the plates through, and the degree of coating received is determined by the speed of transition.

All Tin Used is Imported.—All tin used in coating tin and terne plate is imported from the East Indies. The value of the 32,984,136 pounds of pig tin imported in 1900 was, in round figures, $9,000,000. The world's production that year was 80,000 tons, of which 20 per cent. came to the United States. Including tin in bars and blocks, this country used, in 1900, about 30,834 tons, or about three-eighths of the world's production.

Growth of the Industry in the United States.—The production of tin and terne plate increased in the decade beginning 1891 from less than 5,000,000 pounds to 894,411,000 pounds in 1901. Black plates are generally made from Bessemer and open-hearth steel. Fine grades of roofing plates are to some extent made from rolled iron. Statistics show that the production of tin plates is about four times that of terne. There were 57 tin and terne-dipping plants in 1900, of which 25 are located in Pennsylvania, 12 in Ohio, 5 in Illinois and 4 in New York, and the balance elsewhere. Nine-tenths of the black plates manufactured were from Bessemer steel, and one-tenth from open-hearth steel.

General Effects of the Industry.—The production of tin plate at low prices has greatly assisted in the development of several industries, such as canning and packing, and in many other lines. The production of other qualities, useful for roofing purposes, has led to the very extended use of such material for roofs. The industry is the product of three decades of effort and invention, and has attained a degree of vitality which guarantees continuous expansion.

Statistics Showing Condition of Tin and Terne Industry in 1900.

Number of establishments	57
Capital invested	$6,650,047
Number of wage earners	3,671
Wages paid	$1,889,917
Value of products	$31,892,011
Total pounds produced	677,969,600

Tobacco and Its Manufacture.

Early Uses of Tobacco.—The first knowledge ever had of tobacco was brought by two sailors, sent by Columbus into the interior of Cuba, in 1492, who reported having seen the natives carrying firebrands and exhaling smoke from their mouths and nostrils. They used instruments made from hollow cane, forked in the shape of the letter Y, the small ends being inserted into the nostrils and the large end applied to the burning leaves. The practice of chewing tobacco was first observed by Spaniards on the coast of South America in 1502. Cortez found smoking by means of a pipe an established custom in Mexico.

Tobacco Introduced Into Europe.—The use of tobacco soon became quite general in Europe, having been introduced by Hernandez de Toledo, who carried packages into Spain and Portugal in 1559. In 1585 it was taken to England by Sir Francis Drake; Sir Walter Raleigh introduced it to the Elizabethan court. By 1610 the practice had extended as far east as Constantinople, and soon penetrated throughout Europe. It is now known everywhere excepting among a few barbaric people in inaccessible countries.

First Cultivated.—Tobacco was first cultivated by a European, John Rolfe, the husband of Pocahontas, at Jamestown, Va., five years after the settlement of the colony. In 1615 the fields, gardens, streets and public squares of Jamestown were planted with tobacco. It was the common medium of exchange. In 1619, 20,000 pounds of tobacco were shipped to England. It sold well at high prices, and European merchants began to bid for it. In 1621, 60,000 pounds were grown in Virginia, of which 55,000 pounds were exported to Holland, because of its practical exclusion from England by excise duties.

Increased Cultivation.—By 1731 the annual production in Maryland and Virginia had increased to 36,000,000 pounds, and in 1770, in all the colonies, to 66,780,000 pounds, and by the time of the American Revolution the production was 100,000,000 pounds per annum, but during that struggle the exports fell to 12,000,000 pounds. The selection, preparation and apportionment of the filler, the cutting of the binders and the wrappers, and the binding and wrapping are all done by hand.

Cigar Manufacture.—The first cigars manufactured in the United States were made in 1811, in Connecticut. In 1860 there were 45 factories in the Connecticut Valley. In 1870 there were 235 factories. Kentucky took up the industry, from whence it extended to other Southern as well as Western States.

Advent of Machinery.—Within the past few years both the cigar and cigarette manufacture has been revolutionized by machinery. The cigarette industry has been greatly centralized in four cities—namely, New York, Richmond, Va.; Durham, N. C., and Rochester, N. Y., producing about 94 per cent. of all the cigarettes manufactured in the United States, nearly all machine made. Everything from the stemming of the leaf to the payment of wages is done by machinery. In the modern cigarette factory the prepared tobacco and the sheets of paper used for wrappings are fed to machines, the edges are gummed, the exact quantity of tobacco is measured, the ends are cut and the cigarettes are packed into boxes, all by automatic machinery.

Method of Manufacture.—Tobacco making has had the benefit of 3,100 patented processes, divided among cigar machines, endwise moving fillers, leaf treating, stemming aprons and stationary rolling tables.

Latest Device.—In one of the latest devices the leaf is fed stem first between the stripping rolls until it is gripped by the gripper rolls, which draw it through, and which separate the leaf from the stem; in another the central vein is cut out; one machine tears the leaf from the stem; some machines feed by automatic oscillating means or by a reciprocating and dropping mechanism; some work by suction appliances.

In some cigarette machines the cigarette is continuous and cut into lengths, in which the tobacco is fed to a ribbon of paper as it is drawn from a spool, the edges passing over a gummed wheel, after which the paper is curved by a tube-forming die, the edges being made to adhere. In some the tobacco rod is formed by an endless belt of tube, next forced by the belt into the wrapping appliance, and then cut.

In the Elliott machine the filler is formed on an endless carrying belt, in a reciprocating trough, and the wrapper is folded by means of wheels carrying it over the carrying belt.

In some of the later machines the prepared filler is placed in the hopper of the machine, which apportions the quantity necessary for each cigar, places the cigar in a binder spread to receive, and rolls it. The wrapper is subsequently added by hand or machinery. The cigarette is made from a specially mild tobacco, and the consumer almost invariably inhales the smoke, which comes in contact with the delicate membranes of the respiratory tract. Each establishment has its secret formula for reducing the harshness of the tobacco, for selecting, blending, saucing and general methods of treatment.

Smoking Tobacco.—The cost of producing smoking tobacco has been greatly lessened by ingenuously constructed machinery, which handles it from the raw product to the packing. Between 30,000 and 40,000 packages are turned out by a single machine in a day of ten hours.

Cut Plug.—Cut plug is a form of shredded tobacco made very compact by pressure. After the leaf is prepared it is pressed into cakes by hydraulic or steam-power presses; the cakes are then cut into plugs with great rapidity by machines; the plugs are then run through machines with vertical reciprocating knives, which cut them into layers of desired size.

Snuff.—The making of snuff is the most complicated of all processes of tobacco manufacture. It comes under two names—dry and moist. The material (dry leaves) is first dampened and finely cut, then subjected to a high temperature and rendered perfectly dry, then ground. Moist snuffs are of infinite variety. After grinding, the snuff flour is subjected to as many different processes and manipulations as there are manufacturers. Many of these involve frequent handling to control the different stages of sweating and fermentation which give a certain character to the finished article. Ingredients are added to flavor and perfume. The larger tobacco factories are gathering under one roof the manufacture of practically everything that contributes to the production and preparation of tobacco and snuff for the market.

Pipes.—The tobacco industry has given rise to the industry of pipe making, which includes a variety of devices. Pipes are made of various materials, from corn-cobs to the finest meerschaums with amber bits. Included in the smokers' supplies may be noted paper cigar cases, cigarette tubes, holders, Turkish water pipes, tobacco bags, clay pipes and bowls, snuff boxes, etc.

Comparative Summary of the Tobacco Industry in the United States.

Chewing and Smoking.	1880	1890	1900
Number of establishments	477	395	437
Capital invested	$17,207,401	$30,841,316	$43,856,570
Wage-earners	32,756	29,790	29,151
Wages paid	$6,419,024	$6,947,158	$7,1[illegible]9,821
Capital invested	$52,793,056	$65,843,587	$103,754.362

Cigars and Cigarettes.	1880	1890	1900
Number of establishments	7,145	10,956	14,539
Capital invested	$21,698,549	$59,517,827	$67,706,493
Wage-earners	53,297	87,000	103,462
Wages paid	$18,464,562	$36,475,060	$40,925,596
Value of products	$63,979,575	$129,698,275	$160,223,152

Stemming and Re-handling.	1880	1890	1900
Number of establishments	52	292	276
Capital invested	$1,089,342	$5,735,610	$12,526,808
Wage-earners	1,534	5,985	9,654
Wages paid	$170,871	$1,128,517	$1,817,067
Capital invested	$1,897,535	$16,209,761	$19,099,032

Toolmakers and Tool Making.

Tools and Civilization.—An analysis of our material civilization, if honestly made, would demonstrate that tools were and are at the bottom of it. Capital, enterprise, capacity for organization of isolated agencies into united energy for production or for exchange of products, capacity to originate and formulate, without which our present civilization would be impossible, are, after all, secondary, and not primary. The toolmaker and user are the giant factors. Tools stand for the difference between past and present civilizations, be the tool an awl, an auger, or a locomotive engine, or a dynamo, or a printing press.

Tools and Mechanism.—While tools and mechanism are distinct, they are, from the broad point of view, identical. The primitive conception of a tool is a device which could be used by the hand, wherein the thought and skill of the user is responsible for results. The conception of mechanism is an aggregation of mechanical agencies which in action cause changes independent of the thought and, to a degree, the skill of the user or operator. The characteristic distinction between earlier and later civilizations is largely in the use of tools.

Influence of Steam.—The special event in the tool industry was the introduction of steam power. Its application multiplied results, cheapened cost, vastly increased the power of man over nature, and brought a multitude of conditions to him which amplified opportunities.

Great Variety of Tools.—To enumerate the tools in use, from the smallest to the largest, is beyond the purpose of this review, even were an enumeration possible. It is rather to their social, economic and even ethical aspects that attention is called. The developments which have been reached in some departments of industry are almost incredible to the non-mechanic. The trend in all lines of industry and in all vocations is toward the minimizing of labor and the increasing of the capacity and the functions of tools, whether regarded singly or united, into more or less complex mechanical appliances.

The Function of Tools.—The most complicated machine is simply a multiplied tool actuated with power. The mechanical genius of the age is animated with a determination and zeal to elevate labor to the dignity of an attendant and director of machinery. The spirit of the age in its ideal assumption is to render toil unnecessary and to transfer to the forces of nature the responsibility of providing for human wants. While this ideal is unattainable, it serves to remind man that toil is but a means to an end, and that in proportion as real progress is made along the lines of intellectual and spiritual development, dependence on the mere human factor of labor declines.

No Limit to Need of Tools.—As the laws of thermo-dynamics and of electricity become more and more understood, it becomes more evident that there is a vaster field for mechanism to occupy. But, while this is true, with every step of progress new necessities appear which in their turn call for human effort. The political economist sees in the future a departure in human effort from direct to indirect production, and recognizes that with every step of progress there arises a greater need of tools and machinery. As there is no measurable or assignable limit to human wants, so there is no assignable limit to the need of tools and combinations of tools.

A Question.—The querulous are often inclined to ask what practical results have been reached by this vast multiplication of means of production, and why it is that with such extraordinary mechanical power there is still so much evidence of want and, as they term it, inequitable distribution. To deal with this problem would lead away from the consideration of the immediate subject, but it is quite safe to assume that society is profiting by the abundance produced as rapidly as the general level of intellectual and moral character is raised.

Benefit of Machinery.—There is a wide difference between primary and secondary necessities. The latter outweigh the former. Much of the benefit of machinery is going to serve and cover the secondary necessities, which may be included under the demands of luxury, taste, travel, adornment, etc. The primary necessities of food, shelter and clothing by no means absorb all the productions of machinery and labor.

The philosopher, if called upon, might easily demonstrate the wisdom and justice of the hidden economic law which carries so much of the accumulated wealth away from the primary necessities to the secondary necessities and the accumulating facilities of vaster production under centralized management.

An explanation is to be readily found in the fact, or rather principle, rooted in the bosom of society, that inventive genius works for the mass and not for the individual, and that the individual can profit by these accumulating resources only after society at large has first appropriated them.

The Multiplication of Appliances.—If this be a true understanding, it offers additional incentive to the inventor, producer and consumer to welcome the multiplication of appliances. The individual can only collect the toll that his labor warrants from the cavalcade of wealth that is rolling along the highway of human endeavor.

An Ethical Problem.—That all vocations and employments will be gradually transformed as to methods of work is as evident as it is inevitable. That unnecessary human effort will be gradually minimized through the steadily increasing perfection of tools is as patent as it is desirable. As this principle is recognized, it will become a monitor to remind man that true progress lies along the line, not of individual accumulation gathered in a struggle with his fellows, but along a higher line of human conduct which recognizes that the good of the whole must first be attained before any permanent and profitable good to the units of the whole can be permanently realized.

Comparative Summary of the Tool Industry, not otherwise Specified

	1880	1890	1900
Number of establishments....	145	462	448
Capital invested	$4,384,109	$11,376,622	$13,690,047
Wage-earners...............	3,151	6,410	7,615
Wages paid..................	$1,489,531	$3,482,052	$3,781,763
Value of products...........	$4,236,568	$10,528,025	$13,360,920

This statement does not cover all the tools made in the United States, by reason of the fact that many tools are made in manufacturing plants, the production of which is included in other output.

Kinds.—Among some of the more familiar tools are anvils, blow-lamps, brushes, boring tools, chasing tools, cups, calipers, drills, lathes, buffs, burners, punches, reamers, hammers, files, scales, levels, tongs, cutters, draw-plates, die-blocks, dies and taps, chucks, draughtsmen's appliances, screws, wrenches, tools of emery, engravers' tools, flexible drills, forges, furnaces for annealing, enameling, melting, etc.; gauges, weights, grinders for various purposes, saws, handles for tools, holders, indicators, measures, liquid and dry; micrometers, milling attachments, needles, oil-stones, optical tools, pipe-cutters, instruments and tools for using wire, plumbs, levels, polishing tools, power-punches, wood, metal, leather and stone tools; punches and cutters for all purposes, rod-cutters and shears, rules and ruling machines, repairing tools in various industries, railroad-equipment tools, oil-well tools, blacksmiths' tools, silversmiths' and engravers' tools, steel burnishers, twist-drills and house-building tools.

American Genius.—The genius of American mechanism is in the making of tools to take the place of the hand and to multiply the product. The industry of tool and machine making is now one of the best-developed, and out of it has arisen the great engineering plants where ponderous mechanical appliances are turned out to perform, through the motive power of steam, electricity and water, enormous services. The small tool in the hand of the mechanic was the prototype of the mighty tool which represents thousands of horsepower. While it might be said the line of demarcation between the tool and the machine is where the man ceases to use it and steam or electricity begins, yet the greater machine is but a tool, only indued with greater efficiency.

Civilization may be said to be measured by the progress of tool making. The most remarkable progress has been in the domain of the hand tools, and there is scarcely any line or character of work which, formerly done mainly by hand, is not more rapidly and economically done by tools. The earlier tools were designed for use in handling wood, stone and leather. Later tools were devised to use in iron and steel, and with the improvement in the quality of steel these tools were brought to a higher degree of efficiency, and a multitude of finer tools appeared, which developed into instruments for chemical manufacturing, surgical and a great variety of purposes. The power of steam, and later the electric current, vastly broadened the domain of tools; they invaded the domain of instruments, to the enormous expansion of productivity and subservance of economy, and which has made possible the mighty accumulations of visible wealth and mechanical power.

Latest Tool Making.—The latest development in tool making is in the direction of embodying several tools in one machine, virtually constituting a number of tools, a machine which is capable of simultaneously conducting a number of operations in the shaping of material. The drift is from the manual use to power use, of which the pneumatic tool is at present the highest manifestation.

Trunk and Valise Industry.

Trunks.—The conditions and requirements of modern life call for a multitude of conveniences and appliances which sustain in profitable activity several hundred minor industries. Among these may be mentioned the manufacture of trunks and valises. In earlier traditions, receptacles for the transportation of clothing were made of bags of crude material roughly woven; later on, leather became somewhat generally used, but as soon as railroad traveling facilities were afforded, trunks, most of which were early covered with the skins of animals, retaining the hair, were manufactured in large numbers. Later progress developed trunks strengthened with iron and more or less encased with it. They were divided into compartments to hold various articles of attire and use and were lined with paper or cloth.

Improved Processes.—Various improved processes have been introduced, many covered by patents. The trunk became a most necessary adjunct of travel as well as a convenient receptacle in the household. The industry has developed rapidly, especially within the past twenty-five years.

Statistics.—In 1880, 265 factories were devoted to the manufacture of trunks and valises, which increased to 395 in 1890, and fell to 391 in 1900 through consolidation of factories. Wage earners increased from 4,534 in 1880 to 6,032 in 1890 and 7,084 in 1900. Capital invested, from $2,792,256 to $6,900,756 and $7,046,649 in the dates mentioned. The value of products increased from $7,252,470 in 1880 to $10,821,621 in 1890 and to $12,693,225 in 1900. Much of this stimulus was due to the demand for trunks to enable commercial travelers to carry their wares from town to town.

Valises.—The manufacture of valises increased correspondingly; almost all kinds of leather are utilized in the manufacture, the finer grades being preferably used in a great bulk of the work. Rare skins have recently been more or less utilized for the manufacture of valises, and their convenience and utility has created large and expanding demands. The manufacture of valises on the present scale of magnitude is mainly due to the requirements created by the railway system. The traveling habit of Americans has enabled this industry to double its production within a quarter of a century, and at the present time expansion of manufacturing capacity is being stimulated and manifests itself in the erection of large plants especially equipped with appliances.

Tubes of Metal, Manufacture of.

Latest Manufacturing Processes.—The vital feature in the manufacture of metal tubes was the invention of tubes by the seamless process. There are three processes, as follows: Passing a heated solid rod endwise between the working faces of two rapidly rotating tapered rolls set with their axes at right angles to each other; second, forcing a tube into a rapidly rotating die, whereby the friction softens the tube and the pressure and rotation of the die spin it into a tube of reduced diameter; third, placing an ingot in a die and forcing a mandrel through the ingot, thereby causing it to assume the shape of the interior of the die and greatly condensing the metal.

Butt-Weld Tubing.—The manufacture of butt-weld iron and steel tubing was greatly improved in 1897, and this was followed by an improvement in the manufacture of drawn tubing by clearing the oxide from the interior and exterior of the blank by means of a blast of chilled shot directed against it, instead of by chemical treatment previously adopted.

Tubing from a Cold Blank.—In September, 1900, a further improved process was introduced in a machine which made tubing from a cold blank by an electric welding process. An improvement in 1899 introduced a better method of assembling pipe sections, the joints between the several sections being formed by hydraulic pressure while supported within a jig or mold.

Growth of Pipe Making.—The pipe-making industry has been enormously stimulated by extraordinary industrial expansion during the past quarter of a century, and has been centralized, the greatest plant being at McKeesport, Pa., where mechanical appliances representing all the latest inventive achievements are harnessed in the production of pipe, which finds sale throughout the United States and all the civilized world.

The social conditions of this age, the extraordinary industrial expansion, the feverish commercial activities, the demands for conveniences of water, oil and gas, all have united to create a demand for pipes and tubes to carry fluids and gases in residences, manufacturing plants and for municipalities, and for numerous other utilities, which have created an industry of phenomenal magnitude. The growth of this industry is due to the enormous strides made by the steam engine throughout the whole field of industrial activity. The use of pipe is to carry power from the point of generation of power to point of application and use.

Turbine Wheels and their Possible Future.

The Turbine Engine.—The turbine engine has suddenly arisen into prominence as a possible substitute for the mammoth and superb triple and quadruple expansion engines on steamships. The new turbine is known as the Parsons turbine, and one near Pittsburg, Pa., directly connected with an electric generator, is capable of producing the equivalent of 12,000 horse-power, which is over double the power of the great turbine at Niagara.

Its Diminutive Size.—The remarkable feature of this improved construction is that it is only eight feet high and is simplicity itself. Steam turbines are rapidly coming into use. They afford economy of space, steadiness of motion, are simple in construction and are easily handled.

Turbine Power in Use.— Up to the month of March, 1904, over a half million horse-power of the Parson's turbine was in use. Nearly one hundred thousand horse-power is generated by these engines on steam vessels, and large engineering plants are now busily at work filling orders for them.

Its Economic Importance.—This little turbine is threatening the mighty quadruple expansion engines, which is so costly in operation, construction and repair. It can almost be placed inside one of the cylinders of the enormous steamship engines. With no greater consumption of coal, it generates as great energy, which is instantly converted into electric force through the electric generator. This invention is the most threatening as well as the most promising invention in the generation of power which has been brought before the world for a generation.

Turpentine and Rosin Industry.

Products of Resin.—The gathering of resin or crude turpentine from the long-leafed pine is one of the oldest industries in America. The principal products of the industry are resin, spirits of turpentine and rosin. The latter two are obtained by distillation of the true resin. Tar is obtained by the destructive distillation of the wood itself. Oil of rosin, oil of tar, common pitch, brewers' pitch, etc., are obtained by a redistillation or by a combination of the products mentioned. In the early stages of the industry the crude resin was shipped abroad for distillation, and the export of it gave rise to considerable shipping.

Crude Turpentine.—In 1834 the introduction of the copper still led to a largely increased yield of volatile oil, and the industry received a strong impetus. The methods of distillation have not changed materially during a hundred years. The object is to obtain the largest possible quantity of spirits of turpentine from a given quantity of resin. The quality of spirits obtained depends largely upon the character of the crude turpentine and the skill of the distiller. Crude turpentine is composed of "dip," which is the gum in a liquid state, and "scrape," which is the solidified resin scraped from the tree. The best quality is obtained during the first year the tree is worked, and is known as "virgin dip" or "soft white gum." It is almost colorless, and contains the largest quantity of volatile oil. In the following year the gum is of a deeper yellowish color, and is known as "yellow dip." Each succeeding year it becomes darker and poorer in volatile oil.

Distillation.—The process of distillation requires experience and care to prevent loss of spirits of turpentine. The finest grades of rosin are largely used in the manufacture of paper, for sizing of soaps and of fine varnishes; the medium qualities are mostly consumed in the manufacture of yellow soap, sealing-wax in pharmacy and for other minor purposes. The lower and lowest qualities are used for pitch in ship and boat-building, brewers' pitch and for the distillation of rosin oil, which enters largely into the manufacture of lubricating agents.

Comparative Statement of the Turpentine and Rosin Industry.

	1880	1890	1900
Number of establishments ..	508	670	1,503
Capital invested	$1,866,390	$4,662,390	$11,847,495
Wage-earners	10,535	15,266	41,864
Wages paid	$1,623,061	$2,906,547	$8,393,438
Value of products	$5,876,983	$8,077,379	$20,344,888

Type-Founding and Electrotyping.

Type.—The first permanent type-founding plant in the United States was established at Philadelphia in 1796 by Archibald Binny and James Ronaldson. A foundry for the manufacture of type, principally German type, had been established in 1735 at Germantown, a suburb of Philadelphia, where the first quarto Bible was printed (in German) in the United States. Binny improved the art of casting, which was the greatest step of progress since the invention of printing, and increased the rapidity of production. He made brevier, bourgeois, long primer, small pica, pica and two-line letters.

Metallurgy in Type-Founding.—The science of metallurgy is illustrated in the operations of a type-foundry. Lead, tin, antimony and copper are the chief ingredients used. Lead gives ductility and malleability; tin imparts toughness, is least acted upon by air and water, and acid has but little effect upon it; antimony gives hardness and does not rust; copper adds increased toughness and hardness. The formula for mixing the different metals varies according to the character and size of type.

Type Metal.—Type metal is variously made. Among the compositions used are: 9 parts lead to 1 of antimony, which forms common type metal; 7 parts lead to 1 of antimony, which is often used for large and soft type; 6 parts lead and 1 antimony, for large type; 5 lead and 1 antimony for middle type; 4 lead and 1 antimony for small type, and 3 lead and 1 antimony for the smallest kinds of type.

White metal is made of tin, 82 parts; lead, 18; antimony, 5; zinc, 1; and copper, 4 parts.

Printers' type is frequently made of 6 parts lead and 2 of antimony, and is softer than tin and copper and harder than lead.

Stereotype Metal.—The best way to make stereotype metal is to melt old type, and to every 14 pounds add about 6 pounds of grocers' tea-chest lead. This lead should be melted over an ordinary fireplace to cleanse it, using a little tallow. It should be stirred briskly. In mixing lead and type metal there must be no bits of zinc, as it would spoil all. It takes 80 degrees higher heat to bring it into fusion.

Making the Matrix.—Matrices give the type face; these must be made to a degree of fineness in comparison to which a hair is bulky. The tools used in matrix making are exceedingly fine and delicate, according to the style and character of the letters to be made. Only an engraver can cut the punch or steel letter. The steel is subject to a special annealing process, and is retempered for driving into copper. In this fine work magnifying lenses and numerous delicate tools and instruments, made to measure to the ten-thousandths of an inch, are used.

Three Different Methods. — Three different methods are followed in making matrices. The most satisfactory are produced by the electrolytic process, by which whole fonts, including ornaments, can be made at once in large or small quantities. Pieces of metal softer than type metal have letters cut on them sharp and clear, which are reproduced by battery action, causing copper to be deposited around the face of the type in the holes of the brass plates. The portions not intended to be exposed to the action of the battery are covered with wax before they are put in. It is the matrices that give the type character, accuracy and face value.

Making Type Molds.—The progress in typemaking for the past four hundred years has been due to improvements in molds. Usually there are twelve or thirteen pieces of steel in a mold, all fastened together very solidly and adjustable by steel screws. This mold weighs about a pound, and is as slippery as silk. Each piece is ground to proper size and shaped on laps of lead, tin and emery.

Nicks in Type.—The nicks are cut in the steel and ground to required standard so as to prevent a burr on the type. It takes an expert an hour to make and fit a single nick in a mold, and some molds have as many as four nicks.

Alignment.—Alignment of letters is secured by adjusting a piece of perfectly flat steel to a seat on the lower register, held by a screw, in which a piece of brass one-sixty-fourth of an inch thick is inserted to raise or lower the line of type in the casting. The variation of one-ten-thousandth of an inch in the gauge of a mold condemns it. The mold must be made sufficiently large to allow for shrinkage, and the type produced must be referred to a "standard."

The molds are precious and delicate, and are guarded from changes of temperature. After three months, molds require readjusting. Molds now in use average about 40,000 type per day.

Casting Type.—The casting machine is provided with adjustable pipes for cooling. A pump forces the metal into the molds, each revolution filling it. For small orders and job work, the hand-casting machine has the advantage over the modern steam-casting machine as well as the automatic perfecting machine.

The Automatic Perfecting Machine.—The first machine came from Germany, and was followed by English makes. These machines have been much improved by American type-founders, by which the type is dressed and finished. The automatic space and quadrat machine produces double the quantity of type over the hand machine.

The American "Point" System.—In this system of point bodies, one point equals one-twelfth of a pica. Therefore pica is twelve-point, brevier eight, nonpareil six, and so on.

Brass Rules.—There are between five hundred and six hundred distinct designs or faces of brass rules. There are single, double, treble lines, parallel, dotted, hyphen, block, wave and turned rules.

Electrotyping.—Electrotyping is accomplished by both mechanical and electrical means for the production of typographical composition. The reproductions are termed electros and electrotypes. An electro is produced by the molding of an original and coated with a galvanic deposition. Next a fusible metal is run in at the back of this deposition, and the plate is then mounted on wood.

The first operation in mold making consists in taking the impress of the engraving to be duplicated, for which purpose different ingredients are used, among which may be mentioned a mixture of white wax, spermaceti, stearine and plumbic carbonate in the following respective proportions in grams: 200—30, 250—30.

Another mixture is, glue, 400 parts; molasses, 100 parts. Another, 280 grams bismuth, 190 lead and 100 tin. Best results are obtained in the latter case by first melting the metals and pouring them in a vessel of cold water, with a small quantity of straw and hay cut into short lengths. This is stirred while the molten metal is being poured in. This divides the metals into shots, which are dried and melted again.

Melted beeswax is poured into a slightly warmed molding case, then shaved to required thickness, rubbed with black-lead and polished. It is then ready for the impression, which is accomplished in a molding press. The process of "building" consists in patching defects. Black-leading follows to impart a conducting surface to the copper. After polishing the mold, the superfluous black-lead is washed off and a film of metallic copper is deposited, composed of a solution of sulphate of copper and iron filings.

The Dynamo Electric Machine.—A bath containing a solution of copper is acted upon by an electric current produced by a dynamo electric machine, which passes through the bath, precipitating copper on the face of the impression. Science and chemistry are intimately concerned in the production of an ordinary electroplate.

Making Up of Fonts of Body Type.—The proportion which one letter should bear to another is not agreed upon. A usual proportion is: lower case e, six pounds; a, n, o, four and a half pounds each; h, r, s, t, three and one-half pounds each;

m, d, three pounds each; i, two and one-half pounds, and other letters varying from two pounds to two ounces. The greatest type-foundry in America is that of the MacKellar, Smiths & Jordan, long known popularly as the Johnson Type-Foundry, located in Philadelphia, Pa. For two or three generations this firm manufactured type for all civilized countries in the world, and in many languages.

Comparative Summary of the Type-Founding Industry.

	1880	1890	1900
No. of establishments.......	48	38	22
Capital invested.............	$2,772,690	$4,968,309	$2,269,370
Wage-earners	1,986	1,950	1,424
Wages paid................	$958,693	$1,121,511	$803,470
Value of products...........	$2,330,208	$3,916,904	$2,842,384

Typewriters.

The Early Typewriters.—The first typewriter invented in the United States was called the typographer and was patented in 1829 by William Austin Burt, of Detroit, Mich. In 1843 Charles Thurban, of Worcester, Mass., patented a writing machine which did good work, but slowly. Although practically a failure it embodied some of the principles involved in the construction of the modern typewriter. In 1847 and 1856, A. Ely Beach, of New York, secured patents on a machine involving the system of type bearing levers arranged in a circle. An inked ribbon was used and a bell indicated the end of the line. In 1857, Dr. W. S. Francis, of Newport, R. I., patented a machine provided with a circle of type-bearing hammers attached to a keyboard. Pressure on a key sent the type upward, making an impression through an inked ribbon on paper.

An Improved Machine. — In 1868 C. Latham Sholes, Samuel W. Soule and Carlos Glidden, all of Milwaukee, Wis., greatly improved the machine. James Densmore improved this machine and arranged with E. Remington & Sons, gun manufacturers at Ilion, N. Y., to make type-writers, which have since been known as the "Remington."

The Commercial Typewriter.—It was not until 1874 that typewriters were placed on the market; naturally they were received with skepticism. But so great was their usefulness that they began to be purchased by progressive business houses. The Government early adopted this machine in all its departments in the early eighties, excepting the Department of State, where, until 1897, all official communications were written by hand. Ceremonial letters addressed to sovereigns are still hand-written.

Popular Use.—The typewriter soon received the unqualified approval of the commercial and professional worlds and by State and national legislatures, and hundreds of patents have been taken out for improved attachments as well as for new style typewriting machines.

Book Typewriter.—Among the most noticeable advancements is the book typewriter; latterly inventors are directing their energies to power typewriters, in which class of machines the operator has merely to touch the key with sufficient force to release latch mechanism, whereupon power from an external source completes the impression.

Electrical Typewriters.—Electrical typewriters are also being brought out of wonderful efficiency. In this class of machines the impression mechanism is operated by magnets, the circuits being closed by the operator touching the key. One of these electrical patents discloses a permutation system of type selecting means, which involves fewer keys than the ordinary keyboards of typewriters, the combination of two or more keys being required to operate a single type bar. In this class of typewriters 1,856 patents have been issued.

Early Flashes.—While it was in the United States that the first practical typewriter was made, the idea had birth elsewhere. In 1714 the English Government granted to Henry Mill a patent for a typewriting machine. It was described as "an artificial machine as motive for impressing or transcribing letters singularly or progressively in writing, whereby all writing whatsoever may be engrossed on paper or parchment so neat and exact as not to be distinguished from print." In 1833, Zavier Progrin, of Marseilles, was granted a patent for a "machine that would print almost as rapidly as one could write with an ordinary pen. But these flash lights of mechanical genius can be disregarded and full honor and credit be given to those American inventors whose names have almost become household words. The early typewriters were regarded as mechanical curiosities. The commercial history of the typewriter began about 1880, up to which time its progress had been one of discouragement and failure.

Successes. — One of the first successes of the typewriter was the success had through it in transcribing court records. The first well-organized manufacturing firm was that of Wyckoff, Seamans & Benedict, which was organized in Ilion, N. Y., August 1, 1882. A contract was made with E. Remington & Sons, of Ilion, conceding to the new firm the selling agency of the whole world and the work of improving the machine to meet the requirements of the world's work and of educating the world itself into acceptance of the value of the new device as a labor-saving machine.

Agencies. — The establishment of agencies in Europe led to the sale of the American typewriters abroad, where for years they have been sold in every European capital and important commercial city. By adapting the machine to the Russian language, a large business has been built up. Machines are now made to write various foreign languages. Two late triumphs are a machine for writing the Burmese character and another which masters the intricacies of the Arabian language, the common vehicle of thought for millions of people in the Oriental world. Several varieties of this wonderful machine are now in common use, some of them embodying peculiar and distinctive features. Unlike many mechanical devices, the price has been maintained at practically the same level, though creditable efforts, though not with pronounced success, have been made to reduce the price of machines that would answer the simpler office requirements. Predictions for the future are dangerous. The typewriter has already revolutionized office correspondence and methods.

Manufacturing Centers.—Coming down to the present time with reference to output, New York ranked first, producing 55.2 per cent. of the entire output for the year 1900. Connecticut came second and New Jersey third. The total value of exported typewriters increased from $1,453,117 in 1897, to $2,647,544 in 1900, or 38.9 per cent. of the total product. Europe has always been a large purchaser, having in 1900 taken 83.3 per cent. of the total exports, of which 48.7 per cent. went to Great Britain. The total number of typewriters made in 1900 was 150,410.

Comparative Summary of Increase in the Production of Typewriters.

	1890	1900
Number of establishments	30	47
Capital invested	$1,421,783	$8,400,431
Wage-earners	1,631	4,340
Wages paid	$945,476	$2,403,604
Value of products	$3.630,126	$6.932,029
Machinery, tools and equipment	$533,548	$2,108,564

Umbrella and Cane Making.

Materials Used.—The industry of manufacturing umbrellas and canes has grown with remarkable rapidity during the past few years. Within ten years the factory output has doubled in value. The industry is diversified into several branches, the chief of which are the manufacture of the stick, the production of the steel and its manipulation in appropriate form for the umbrella-maker, the cutting and the preparation of silk, cotton or other goods used, and the manufacture of the metallic attachments, to say nothing of the plating of the same, where plated. The silk used is particularly designed to resist moisture, and the cotton goods and other materials used are usually selected with special view to umbrella purposes.

Their Early Use.—As a defense against rain the umbrella came into use in England about the middle of the eighteenth century. It was originally intended to be used between the door of a residence and the carriage, and was, when first introduced, used by wealthy persons only. It was introduced from the far East, where it has been used by all classes from the remotest times, and was at one time, in Europe and Asia, considered a symbol of royalty or dignity. The usual materials used to-day in its manufacture are silk, cotton, alpaca and other fabrics.

Canes.—Canes are made from acacia, asp, ash, bamboo, bakow, bay tree, black tork, boxwood, briar, cabbage, cherry, cedar, chestnut, coffee, cork, ebony, eucalyptus, hazel, holly, lancewood, myrtle, oak, olive, orange, partridge, rajah, rattan, snakewood, thistle, whengee and a number of other woods. Bamboo canes come largely from the far East, where they are prepared in primitive ways. By far the largest number of sticks in use is known as natural sticks, which are saplings or clinging plants, where the roots have sufficient character to form handles or knots.

The feature of the industry of recent years has been the centralization of production and the enlargement of plants, the production of large quantities of goods of fixed market values, the use of machinery for the greatest possible output at the least cost, and the combination of all the various processes of manufacture in one plant. The production of steel of suitable quality; furnished in convenient shape for immediate use has also aided in the rapid growth of this important industry.

The industry has practically doubled its production in the last quarter of a century and is expanding rapidly, at the behest of custom, fashion and utility.

Comparative Summary of the Umbrella and Cane Industry.

	1880	1890	1900
Number of establishments...	172	435	261
Capital invested............	$2,658,725	$5,646,289	$4,677,917
Wage-earners..............	3,608	6,022	5,695
Wages paid.................	$1,158,682	$2,435,860	$1,889,673
Value of products..........	$6,917,463	$13,771,927	$13,855,908

Undertaking and Embalming.

Coffins in Ancient Times.—Coffins were in use from remotest antiquity. The only mention made in the Bible of a coffin was where it states in Genesis that the embalmed body of Joseph was laid in one. Coffins were in general use among the Jews; some Egyptian coffins were made of wood, though stone coffins — sarcophagi — were largely used, some covered with hieroglyphics, which are now conspicuous objects in the Egyptian room of the British Museum. There were coffins of baked clay in Messopotamia; cedar wood was used in Athens as material for coffins for the dead bodies of her heroes. Marble and stone coffins were used by the Romans. Coffins have been used in the British Isles from the remotest time.

Coffin Manufacture.— It is within comparatively recent date when coffin making became an industry in the United States. Prior thereto the work was restricted to cabinet makers or carpenters, or workmen handy with tools. For many years coffins were made of commoner forms of wood, excepting where the wishes of families led them to direct the use of more expensive woods. Still later the introduction of metal coffins became quite general and the industry at this time is quite an important one.

Trimming of Coffins.—After the construction of the coffin itself, whether wood or metal, it is subjected to the art of upholstery, as it were. The materials used include several kinds of silks, satins, velvets and various other materials; also laces and fringes; the outside is ornamented with handles of silver, oxide, gold and silver, together with a name-plate, with name, date of birth and death of deceased thereon.

Embalming.—The art of preserving the dead bodies of men or animals originated in Egypt, and has been in use over 3,000 years. The practice also prevailed in Asia; among the poorer classes bodies were dried in sand. Embalming was also performed by drying, salting, or boiling, in resin and bitumen; also by using fine resins, myrrh, cassia and other aromatic substances. Sometimes the body was steeped in a solution of natron for seventy days, then swathed in linen bandages saturated with gum, in some cases 1,000 yards of linen being used.

Dr. Richardson, in 1854, found that liquid ammonia injected into animal structures preserved them for a long time. Simple wood vinegar has been used successfully as also a solution of zinc chloride. Brunetti's method consists in injecting alcohol to abstract water, ether to abstract fatty matters; after this tannin is injected and the body is then dried in a current of warm air passed over calcium chloride. Another process employs calcium chloride slowly heated to 212 degrees. The solutions for this purpose are numerous.

Statistics.—There are 217 establishments manufacturing coffins and undertakers' goods, employing 6,840 workmen. Value of products, $13,952,208; invested capital, $13,585,162; wages paid, $3,077,481. The value of coffin trimmings in 1890 was in the neighborhood of ten million dollars, in which 2,000 workmen are engaged in 1,500 establishments.

Washing Machines and Clothes Wringers.

Hand and Power Machines.—Hand and power washing machines have been greatly improved during the past few years. One of the latest power washing machines has a rotating cylinder containing the clothes, which is provided with an arrangement of pipes by which either steam or water or blueing can be introduced into the cylinder through its hollow journals as desired, so that the clothes can be washed, rinsed and blued without removal from the machine. A very valuable machine is on the market in which the cylinder is provided with reciprocating perforating pistons between which the clothes are alternately squeezed and released; it allows a supply of fresh water to be constantly introduced through one of the hollow journals of the cylinder while the water that has been used is constantly discharged through the other journals.

Later Machines. — Another popular washing machine has a casing in which is journaled a perforated cylinder in which the clothes are placed, one end of the cylinder being provided with propeller blades which force a continuous current of water from the casing through the clothes, these blades being assisted by spiral blades on the periphery of the cylinder.

The Oscillating Squeezer.—A valuable washing machine of wide acceptance has an oscillating squeezer extending across its center. When the tub is oscillated the clothes on opposite side of squeezer are thereby pressed, valves on opposite side of the squeezer being alternately opened and closed during the oscillations to remove the dirty water.

Starching Machine.—A machine for starching fabrics has a starching roll, which runs several hundred times faster than the drum upon which the goods rest. This generates the frictional heat at the point where the rolls act upon the goods, the starch being cold when it is discharged on the fabric.

Different Makes.—Many machines are made to move the clothes through the water, while some machines force the water through the clothes and rub them at the same time. There are special machines made to wash carpets and bed spreads and miners', machinists' and laborers' clothes. The bearings on some of these machines are as fine as those on a bicycle. They are provided with oil-tempered coil springs, two in number, which engage at each extreme point and help to reverse the motion. This machine moves uninterruptedly until it reaches the reversing point, when it comes in contact with the force exerted by the springs, and like the action of a rubber ball, bounds back, meeting the spring force again at the other extremity.

Wringers.—Among some of the well-known wringers are the heavy power wringers, the heavy galvanized iron frame, steel spiral springs which are adapted for manufacturing establishments, bleacheries, tanneries and the like. Light power wringers are also made in large numbers with high-grade rubber rolls and of galvanized malleable iron frame, which are also used largely by manufacturers. Wringers are also built for blue print purposes, similarly manufactured. Each machine is furnished with a crank for hand power and is supplied with tight and loose pulleys and belt shifter when wanted. The rolls are reversible, so that the crank can be placed at either end as desired. Some wringers are constructed with heavy brass washers and journals to prevent rust where acids are used and the rolls are so constructed as to permit all grit and dirt to wash off the ends of the rolls before running in the journals. When the pressure is off the upper roll, it rises clear of the lower roll, and both are thus kept true and round.

The laundry industry has been built up to a very great degree by the excellence of the mechanical appliances used. Domestic labor has been very largely minimized by appliances of excellent construction and durability specifically adapted to household requirements. The use of these machines and wringers is steadily expanding and the industry, as the statistics reveal, is in a prosperous condition. The production increased 3½ times within twenty years.

Comparative Summary of the Washing Machine and Clothes Wringer Industry.

	1880	1890	1900
Number of establishments...	61	163	118
Capital invested............	$652,549	$1,712,953	$2,404,569
Wage-earners..............	476	1,030	1.509
Wages paid.................	$176,287	$430,888	$548,707
Value of products..........	$1,182,714	$2,489,175	$3,735,243

Watches and Watchmakers.

The Watch.—The industry of watchmaking is one of the most interesting in the domain of handicraft. The watch is an exponent, in a certain sense, of the nervous energy of the people. An old writer said, "Time is made for slaves," but man is a most willing slave. A watch is a monitor, admonishing us of pressing duties and of overwhelming activities, and is a most valuable companion in the race of achievement.

Introduction of Machinery.—The United States leads the world in watch construction, and has taught the watchmakers of other lands how to use machinery in watch manufacture. The watch came to the United States from the Old World perfect in principle, but here methods of production were revolutionized. The English were the first successful watchmakers, and routed the old-time hour-glass, except as a languid curiosity. They so thoroughly applied themselves to manufacturing watches that, as long as a century and a half ago, the labor of watchmaking was divided into 102 distinct divisions.

Watch-Making in Switzerland.—Switzerland took up the industry of watchmaking and transformed it largely into household employment. The earliest watches took a year for manufacture, and their cost at that time was upward of $1,500; the daily variation amounted to from forty to sixty minutes, but this was gradually reduced to seconds.

Expansion of Capacity.—Machinery, however, under the genius of American mechanics, wrought a mighty revolution in shop methods and in commercial movements. The prejudice long existed that hand-work on watches produced more exact results; but since the introduction of American mechanical methods, this notion has been dissipated. Under our methods about five months are required to finish a watch, all operations proceeding simultaneously. The average output of the 40,000 Swiss workmen engaged in the watchmaking industry is 40 watches each, yearly.

Increase of Production.—The average production in the United States, per workman, increased from 150 in 1880 to 250 in 1900, and since then a further gradual increase has been made, which, it is expected, will reach an average of a watch per day.

Where Watchmaking Began.—It was in 1838, at Hartford, Conn., that the first commercially successful application of machinery to watchmaking was applied, but the project was for some reason abandoned until 1851, when another similar attempt was made at Roxbury, Mass. In 1853, thirty-six-hour watches were put on the market. Further efforts followed, the great difficulty encountered being the manufacture of automatic machinery to produce the delicate action necessary. Most of this fine machinery remains unpatented and is most zealously guarded.

Development of the Industry.—Watchmaking centers gradually developed — one at Waltham, Mass., one at Nashua, Vt., and one at Elgin, Ill., and at localities in New York, Connecticut and elsewhere. The number of scientific and mechanical appliances which have been brought out in the manufacture of watches is greater, perhaps, than in any other industry for the capital engaged, especially in the perfection of automatic machinery. The watch factories of the United States are equipped with automatic and semi-automatic machines, which rapidly make a large number of parts of perfect uniformity at small cost; six or seven machines can be attended by one operator.

Plate Turning.—A surprising invention has been developed within a few years, manifested in two automatic machines of exceptional merit for plate turning, which turn six recesses in the train side of the pillar-plate for the barrel, escape-wheel, pallets, balance for the center pinion and a bearing for the intermediate setting-wheel. Bossing is accomplished by a modification of the tool movement, and a change of chucks accomplishes the turnings of the dial side of the plate. The remarkable features of these machines are seen when it is remembered that the watch-plate must be placed in each succeeding chuck in a different position, and that it must be placed on three pins which fit in the dial feet-holes.

The Chuck Automatic Cutter.—For the cutting of pinions this cutter cuts in direct connection with the turning from a long rod wire. This, with the crown-cutter wheel and machines for the manufacture of minute screws and stud-pins and of vibrating balances and hair-springs, constitute a collection of minute mechanical appliances which do honor to American ingenuity.

Hair-Springs.—The casting of hair-springs has admittedly reached the highest state of improvement. The wire is drawn to exact diameter and flattened by repeated rollings, and then polished. A system of testing springs and the grading of springs according to strength has been worked out to absolute exactness.

Minuteness of Screws.—Some watch screws are so small that it requires 150,000 of a certain kind to weigh a pound, and under the microscope they are seen as perfectly finished. The pivot of some balance-wheels is one-two-hundredth of an inch in diameter, and the gauge with which pivots are classified measures to a ten-thousandth part of an inch. Each jewel-hole into which a pivot fits is about one-five-thousandth of an inch larger than the pivot, to permit sufficient play. The finest screw for a small-sized watch has a thread of 260 to the inch and weighs one-one-hundred-and-thirty-thousandths of a pound. Jewel slabs of sapphire, ruby or garnet are first sawed into slabs one-fiftieth of an inch thick, and shellaced to plates. A "pallet" jewel weighs one-one-hundred-and-fifty-thousandths of a pound, a "roller" jewel one-two-hundred-and-fifty-six-thousandths of a pound. The largest hair-spring is four-one-hundredths of an inch in diameter and about nine-one-hundredths of an inch in length.

Testing.—The hair-springs are selected by girls possessing an extremely fine sense of touch, aided by machines, and put in the balance and then corrected by the twin screws of the balance. The movement is adjusted by being put through all the tests for heat and cold from 95 degrees to 38 or 40 degrees. The balance in most modern watches is required to make 18,000 vibrations an hour. The change of one beat will make an error of four and four-fifth seconds in twenty-four hours.

Low-Priced Watches.—The long-wind Waterbury watch appeared in 1878, and was the outcome of the improvement of the old duplex escapement, but this improvement has been supplemented by a still higher grade of duplex escapement. No jewels are used against which the pivots may rest. Nearly all the parts are stamped out, not cut out. The main-springs and the hair-springs are of the same quality and have been greatly reduced in cost. Very little time is spent in testing and adjusting.

Production.—In one factory alone over 2,000 cheap watches are turned out per day. They are sold to the public as superior to the cheaper Swiss watches, and the claim is not openly disputed. They are exported in large quantities, and drive out European watches by the magic of cheapness.

Hunter and Open-Faced Watches.—English sportsmen created a demand for hunters' watches, and this style is still fairly popular in America, but there is a growing preference for open-faced watches.

Watch Cases.—This branch of the industry has become specialized, and large plants now supply watchmakers with a great variety of attractive designs. Watch movements and watch cases are made for each other, according to standard sizes. The cost of cases is being lowered by improving mechanical appliances which are marvels in their capacity to produce an interchangeability of parts. The metal used for cases goes under numerous processes from the furnace when it is mixed, melted and shaped, through cutting, rolling, turning and stamping, until it receives the final touches of mechanical genius in the finishing department.

Filled Cases.—James Boss, of Philadelphia, in 1859 invented the filled case, which was a tasty, serviceable and durable gold case, at about half the cost of a solid gold case. The kinds of cases in most common use are silver, nickel, silverine, silverore, silveroid, nickel silver, German silver and gun-metal.

Statistical Summary showing Progress of the Watchmaking Industry.

	1880	1890	1900
Number of establishments...	11	19	13
Capital invested............	$4,144,327	$10,106,114	$14,235,191
Wage-workers	3,346	6,595	6,880
Wages paid.................	$1,712,276	$3,587,808	$3,586,723
Value of products..........	$3,271,244	$6,051,066	$6,822,611

Additional Facts.—There were thirty establishments manufacturing watch cases in 1900, which turned out watch cases worth $7,283,960, employing 3,907 workers, and to whom $1,924,847 were paid in wages.

Watch manufacturers have about reached a capacity of one watch per day per employé directly engaged on watch work, which means an annual production of 900,000 watches. The cost of movements of a superior kind ranges from $3 to $75 each.

Water-Power Principles and Mechanism.

Water-Power Facilities.—The remarkable expansion in the use of hydraulic power in the face of the extraordinary growth of steam power, to say nothing of electrical energy during the past few years, may not at first sight be readily understood, but there are many sound reasons for it. It is in the natural order of events and in accordance with the law that force follows the line of least resistance, that the use of water-power should have awaited the wonderful development of steam and electrical power. All conditions are now gradually converging to a focus which will produce a vastly greater use of this power in the near future. Industrial, commercial and financial considerations all point to a great expansion of water-power facilities.

Early Use of Water for Power.—The Chinese were the first to use water-wheels for irrigation. All peoples in historic times have used water for power in some measure, but it was not until comparatively recent times that any scientific application was made of its use. Poncelọt, in 1825, discovered that the float, instead of presenting a plane radial surface to the impulse of the water, should consist of circular arcs. Water-wheels not adapted for great pressures on high falls have been superseded by turbines, which can be used for almost any head or pressure of water. Turbines are very ancient. They were known seventy years before Christ, but it was not until 1827 that their scientific development was brought about.

Epochal Inventions.—Lord Armstrong's invention, in 1851, of a dead weight accumulator was an epochal invention which overcame the defect of deficient water pressure. The development of the Pelton water wheel was another epochal invention, by which 85 per cent. effective duty was secured. These wheels rapidly supplanted many former wheels. In this wheel the power is derived from the pressure due to the head of the water, supplied by a pipe discharged on the wheel through a small nozzle, the size of which is proportioned to the amount of water available, and head and power required. The power of this wheel does not depend upon the diameter of the wheel, but upon the head and amount of water applied to it. The Pelton is a high wheel applied to low falls and has worked as low as 10 feet. Its efficiency is high. Six wheels at Chollar Shaft on the Comstock Lode gave 88 efficiency. These wheels come in three types—single, double and multiple nozzle wheels. Hett's Pelton has an improved nozzle, and in Cadle's "Duplex" Pelton the buckets fit on the disks into recesses.

The Turbine Wheel. — A turbine is a water-wheel with an axis which may be vertical, horizontal or inclined at any angle to suit circumstances. Its advantages are threefold — it does work without material loss of efficiency, moves with greater velocity and can be applied to falls from about 9 up to 100 feet. These wheels are classified as impulse and reaction turbines.

Classification of Wheels.—A second classification is—outward and inward turbines, mixed flow, parallel flow and circumferential flow. The outward flow turbines are those in which the water is directed by the guide blades on the inner surface of the wheels; the inward flow turbine allows the water to enter at the outer circumference and is discharged at the center. The mixed flow unites both features. In the parallel flow turbines, the water continues in a downward direction. The circumferential flow turbine is cheap and simple, in which the water centers tangentially at the periphery and is exhausted from the sides. Great mechanical ingenuity is shown in the regulation of these turbines to accommodate them to the supply of water.

Water-Pressure Engines.—In water-pressure engines, the water acts by its own weight, chiefly. Reciprocating water-pressure engines are only used where non-rotary motion is required. Their variety is great. Armstrong overcame the concussion of water at each reversal by means of relief valves. In Meyer's engine the supply of pressure water is cut off before the piston arrives at the end of its stroke. In Jasper's engine the two cranks are placed at an angle of 90 degrees and the two water-pressure cylinders and the valve chests are surrounded by an air-vessel to prevent sudden changes of the pressure in the valve chests. Among the rotary water-pressure or hydraulic engines may be mentioned Armstrong, Pitman & Escher; Wyes & Co.; among the oscillating, Schmid, Wyss & Studer; Haag, Ramsbottom, Hastie, Brotherhood & Rigg.

Types of Hydraulic Rams.—There are three distinct types of hydraulic rams: those having no air vessels, those having an air vessel, and pumping rams. Among hydraulic rams may be mentioned the Massy, Morrow, Fischer, Hanson, Kerth, Durozoi, Bolii, Blake and Davie.

Industrial Development. — Industrial development can be greatly assisted by the use of the abundant waterfalls scattered all over the United States. Manufacturing enterprise is seizing opportunities rapidly and large manufacturing plants are being erected at points where this cheap power is available, especially where it can be converted into electric energy. A great future is before the manufacturing interests from this assistance, and its development may act as a corrective, in greater or lesser degree, to the centralizing tendencies manifesting themselves in industrial combinations.

Prospects of the Turbine.—The year 1903 saw many additional and highly successful demonstrations of the turbine in marine work. It may be considered a hazardous prediction that certain machinery cannot be improved, yet the statement, is probably correct that the reciprocating engines, as seen in the Deutschland, have reached their practical limit of speed efficiency, having arrived at a point beyond which a higher rate of speed means a cost in operation which is commercially prohibitive.

The Turbine is Coming.—If speedier ships are to be built, they must be driven by some other motor, and the turbine seems to offer favorable prospects for obtaining higher speed upon a more economical basis. The question is whether the same turbine system which has worked satisfactorily in small ships can be employed successfully in a great ocean liner.

Speed Records.—The speed records across the Atlantic for eastward and westward passages are still held by the Hamburg-American Liner, Deutschland (November, 1903), which obtained an average of 23.51 knots per hour over the whole course of 3,082 miles. The greatest daily run of the Deutschland in 1903 was 601 knots (equal to 692 statute miles), or more than any other steamship ever traveled in a single day; the very best trip from New York to Plymouth was made by the Deutschland in five days, seven hours and thirty-eight minutes.

A Dream Fulfilled.—If the Deutschland had been on the Queenstown route, which is several hundred miles shorter than that to Plymouth, she would have crossed the Atlantic in considerable under five days, so that in this splendid product of the German shipyards we already have the four-day boat, the dream of a few years ago.

The Hydraulic Door.—The latest device for insuring safety of passengers aboard ships is the hydraulic door-closing system of Stone-Lloyd, introduced in the Hamburg-American Liner Deutschland, which is thereby rendered unsinkable. The Deutschland is the first great ocean-going craft to be fitted with this mechanism, which closes the twenty-four heavy bulkhead doors in half a minute, operating at a pressure of from 700 to 800 pounds per square inch by simply turning in the wheelroom on the bridge a small crank, scarcely a finger's length, for fifteen seconds.

Very Latest Improvements.—The most wonderful achievement in steam turbines is the high-power Westinghouse-Parsons, of 7,500 horse-power capacity, which have a continuous overload capacity of 11,000 horse-power in one self-contained unit. Turbines for marine work of still greater capacity are being designed. The 7,500 horse-power turbine occupies a space of 27 feet 8 inches by 13 feet 3 inches, and height to top of hand-railing, 12 feet. The 5,000 kilowatt unit operates at 750 revolutions per minute. Power is transmitted to the generator shaft through a flexible coupling, which is split at the lower junction of the two shafts. A crowfoot sleeve is keyed to each shaft, and the power is transmitted to an outside quill engaging the crowfeet. The journals are solid and self-aligning.

Steam enters the turbine successively through an automatic quick-closing throttle, hand throttle, strainer and the main admission valve. An important feature of the steam distribution system is the provision of a by-pass valve. This valve admits high-pressure steam to the second stage of the turbine overloads, in order to increase the capacity up to 50 per cent. in excess of full-rated load, thus securing maximum economy at all times, together with overload capacity.

The main admission valve consists of double-beat poppet valve, operated by a small piston. The valve admits steam to the turbines in puffs, the duration of which is proportioned by the governor to the load upon the turbine. Copious lubrication is provided to all the journals by means of a plunger pump driven from the main shaft.

This powerful machine is employed in heavy electric railway service, and others are being built to operate electric locomotives in the Pennsylvania Railroad terminal in New York City. These units will operate under 175 pounds steam pressure, high vacuum, and 100 to 175 degrees of superheat.

Whalebone and Rattan Manufacture.

The whalebone industry has fallen to restricted proportions in recent years, this valuable product being largely driven out of use, especially for use in corsets, by the introduction of steel, which is found to answer the same purpose, and which is furnished at much less cost. Whalebone is used to a limited extent in the industries and arts, but its main distribution is given over to the dress-maker and corset-maker. The decline of the industry is shown by the fact that the production has fallen from $682,977 in 1890 to $135,000 in 1900. The supply of whalebone is gradually declining because of the gradual extinction of whales, which are mainly found in the Arctic regions. Rattan manufacture has also largely fallen off, because of the ready utilization of substitutes which have been produced in large quantities.

Willowware Industry.

The Willow Tree.—The young willow tree is a slender and pliant tree, known in the books as salix, deriving its name from its flexibility. It serves a very wide use in the manufacture of a number of products, of which baskets are perhaps one of the principal. The bark is useful for tanning, and contains a larger amount of salicine than any other known tree.

Varieties. — The willow prefers waste and marshy situations, and is used in some parts of the world as fagot wood. The goat willow often attains a height of from forty to fifty feet, with a trunk varying from one to two feet in diameter, and is used for hoops, poles, rods, crates, sheep fences and a variety of like purposes. The bulk of the supply, however, for bucket and cooperage purposes comes from the tree known as the "osier." The Spaniard variety is used for bottoms, rims and handles of large baskets. The common osier is soft, coarse and brittle, but the yellow-barked osier has the good qualities of being firm, heavy and tough. It is largely grown in Holland, and is being produced in some portions of the United States. Certain kinds are used for fish baskets and hampers, their ends snapping in the inward and outward working, consequently making inferior work. Other kinds grow tough and slender, and are used for ornamental baskets. The rougher qualities are used by coopers as wooden hoops for wine casks. Among the varieties may be mentioned the skit, the goldstone, the wire hornrod and the water hornrod.

Growth.—The industry in the United States has grown to considerable proportions under the growing demand for many varieties of baskets, useful and ornamental. It is used to a limited extent in a number of the lesser industries.

Comparative Summary of the Basket Willowware and Rattan Industry.

	1880	1890	1900
Number of establishments...	304	403	550
Capital invested...........	$1,852,917	$2,702,713	$2,989,568
Wage-earners...............	3,119	3,303	4,396
Wages paid.................	$657,405	$1.004,021	$1,280,513
Value of products..........	$1,992,851	$3,633,592	$3,851,244

Windmill Industry.

Uses and Kinds.—The importance of windmills as an industrial and agricultural aid is seen in the fact that the annual production is valued at between four and five million dollars. Windmills find the greatest use throughout the West, and are employed largely in the pumping of water for domestic and stock purposes. They are cheaply made, consisting of but few and simple parts, of durable construction, and require no special skill in management. These mills are also used for the grinding of grain and other purposes. When wind is employed as the first mover of machinery, it may be applied either by receiving it upon surfaces vertically or nearly so, and which gives motion to an axis nearly horizontal. This is called a vertical windmill. When the wind is received upon vertical sails or surfaces which move in a horizontal plane, and give motion to a vertical axis, it is called a horizontal mill.

Value to Farmers.—The windmill has been so improved in the United States as to become available even by small farmers. It renders the farmer independent of rainfall for the home. It is estimated that a windmill will irrigate two acres or more, and if a large reservoir is provided, even seven acres can be supplied. The estimate is, of course, based upon the assistance given the soil by rains. To-day windmills are placed on steel towers, on which are erected strong and shapely tanks. It requires but a few hours to put up a windmill, with tank and working arrangements. Pumps are specially built for windmills of great variety and of moderate cost. There are various varieties and kinds of mills, all built on practically the same principle. The economies that have been subserved by windmills warrant their extended use; they economize household, barnyard and farm operations. The best windmills of to-day are made with double gear, and all working parts are between bearings, and are made in all sizes, many ranging in diameter from 4 to 20 feet.

Power of Windmills.—The power of a windmill depends, first, on the diameter of the wheel, and second, on the velocity of the wind. To increase the wheel diameter is to increase its power in proportion to the area of the squares. A 4-foot back-geared mill, in a fifteen-mile wind, gives one-twelfth horse-power; 6-foot, one-fifth; 8-foot, three-tenths; 10-foot, three-eighths; 12-foot, one horse-power, and 16-foot, two and two-fifths horse-power. The mean average velocity of the wind for the entire United States is nearly eight miles an hour.

The Parts.—The parts of a windmill are the hub, arms, double rim and the sails and their fastenings.

Velocity and Power.—Experience determines rules for calculating the efficiency of windmills. Tables are worked out showing the coefficient for various velocities of wind. Starting with 4 miles velocity, the coefficient is found to be 16; 8 miles, 2; 9 miles, 1.4; 12 miles, .70; 15 miles, .50. The daily water consumption is the basis of calculation. The hourly capacity is found by dividing this by 8.

Example.—Take a well to furnish 2,600 gallons daily, velocity of wind 9 miles, water standing 30 feet from ground level, to be elevated to a tank 50 feet above ground. Divide 2,600 (gallons daily water consumption) by 8 (average hours a mill will pump), and we have the hourly capacity of mill (325 gallons). Then multiply the hourly capacity (325 gallons) by the total water lift in feet (30 + 50 = 80 feet), by the coefficient with wind velocity at 9 miles an hour (1.4), and we have 36,400 gallons, the total capacity.

Tower Capacity.—Tower capacity ranges from 2,000 to 10,000 gallons, from 8 feet diameter or less to 12 feet; ordinarily a height of 30 to 40 feet is sufficient. Windmills are rendered frost-proof, and yield uniformly good service the year round. In many places windmills provide a water supply sufficient to fight suburban fires.

Irrigation.—Irrigation by windmills has been measurably effected, and in some cases mills running in a 40-mile wind lift six or more barrels of water per minute, according to size of mill and lift. There are devices for throwing the mill out of gear when water is not wanted, which are termed regulators. Through the medium of a float in the tank, the mill is put into action when the water subsides to a predetermined level.

Comparative Summary of the Windmill Industry.

	1880	1890	1900
Number of establishments...	69	77	68
Capital invested............	$697.100	$2,463,231	$4,308,666
Wage-earners................	596	1,110	2,045
Wages paid..................	$244,197	$555,775	$940,474
Value of products...........	$1,010,542	$2,475,050	$4,354,312

Wire and Wire Workers.

Vast Extent of Requirements.—Recent mechanical improvements for the manufacture of wire represent almost an absolute departure from the old-style methods of wire making. The enormous demands for wire for a variety of purposes have developed wire making into one of the most important industries. The necessities of electric communication, the requirements for wire fencing and the urgent calls from two or three scores of industries for wire for manipulation into multiplied products, have resulted in a diversity of processes for the production of specific qualities of wire. This might not inappropriately be called a "Wire Age," instead of the "Iron Age." Wire has become one of the most important products in the present condition of industrial society, and its utilities are being developed to an extraordinary degree.

Barb Wire. — Power mechanism for barbing fence wire has been advanced to practical perfection. The original patents of Glidden and Vaughan are the foundations of the present wire-making system, though later machines only show remarkable improvements on these great inventions.

The Glidden patent differs from former improvements in having the barb formed of a wire coiled around the longitudinal fence wire instead of having it formed of a perforated plate strung on the wire fence.

The first suggestion of a barb wire fence was in 1861, when a patent was granted in France for that purpose. It was not, however, until the latter part of 1874 that a barb wire machine was patented in the United States. This machine was subsequently improved, and led to the multiplication of wire-working machinery which has since become the basis of one of the greatest industries in the United States. Machines for making wire nails and numerous wire products have since grown to immense proportions. Their round cross section and lack of taper gives them great holding power and saves the grain of the wood. Another branch of the industry has developed along this line, namely, the bending of wire to form chains without welding the links, which in later years has also been extended to heavy chains.

Wire Netting.—Wire netting machines, which were introduced in 1888, have been greatly improved, though by minute degrees. Few types of wire-working devices have made greater or more important advances than machines for building standing wire fences. From the old line and tie fence made by hand, tools and machines have been introduced for wire and picket fence making and all manner of wire fencing, which have shown a steady advance.

Improved Processes.—The importance of the industry is shown in the fact that 1,861 patents had been issued up to 1900. An ingenious machine has found general use for expeditiously wiring corks and bottles. An important step has been taken in fabric making by the introduction of strand and stay wires, which are electrically welded during the continuous feed of the machine.

Electric Coils.—Improvements have been made in electric coil-winding mechanism, wherein the wire is wound into helices, bobbins, etc., and the sheets of paper or other insulating material introduced at intervals.

Wonders of Mechanism.—The great wire-manufacturing plants of to-day are wonders of mechanism, and more wonderful in their capacity to produce enormous quantities of goods with a speed, regularity and certainty that seems to defy the possibility of further invention. The wire products of American factories are in demand throughout the world, and they are furnishing means for the development of conveniences which could never be provided for excepting through the instrumentality of wire.

Among the numerous kinds of wire manufactured are machinery spring, cast steel wire, chain wire, clock wire, charcoal iron wire, musical instrument wire, wire for textile machinery, telegraph and telephone wires, tinned, galvanized and copper wires, brush wire and millinery wire.

Wire is made from copper, charcoal iron, Swedish and Norway refined iron, Bessemer steel, basic or acid open-hearth steel, crucible cast steel and plow steel. Fine steel wire is drawn to .0006 of an inch.

Shapes of Wire.—Wire is also drawn flat for bands, bookbinding, brushes, corsets, curtain springs, dress stays, elevator guards and expansion balances, also for saws, mats, musical instruments, needles, rulers, umbrellas, tape-lines, sash balances, shoe patterns and shanks, and for numerous other purposes.

Wire is made also in numerous odd shapes—square, oval, half-oval, half-round converse, concave, corrugated, angular, diamond and triangular shape. For furniture and other uses it is made into lounge wire for pillows, bed springs, car seats, cushion backs, edge springs, door springs, bicycle saddles, hinge springs, springs for wood-working machinery, extension springs, helical springs, torsion springs, buffer springs and bobbin and loom springs.

Wire Rope.—Wire ropes and strands are made of numerous wires, frequently seven-ply, twisted, and of galvanized wire. Much wire is used in wire clothes lines, in ties for baling, for wire hoops, wire rope fittings and wire rods, the consumption for the latter product being perhaps the largest for any one product.

Barbed Wire. — Barbed wire consumption has also reached enormous proportions, because of the extraordinary demand for fencing purposes, especially in agriculture. It is painted or galvanized, and is sold by number of points, and is rolled on wooden rolls in 50-pound, 100-pound and other sized lots. Among the well-known makes are Glidden 2 and 4-point, Baker 2-point, Ellwood, Junior, 2-point, Iowa 4-point, Lyman 4-point, Waukegan 2 and 4-point.

Wire Nails. — A large percentage of the wire production is used in wire nail manufacture; among the larger varieties are barbed common flooring nails, barbed car, light or heavy; finishing, clinch, casing, fence, hinge, light and heavy; barbed roofing, slating, shingle, lining, barrel nails, tobacco nails, boat nails, spikes and barbed dowels.

Quite a variety of special wire nails are made, known as flat smooth, flat chequered, countersunk, rose head, diamond head, round, oval and flat heads, oval brads, triangular nails, clout nails, lath nails, tram nails, square nails, steel escutcheon pins and double-pointed dowels.

Spikes are made for railroad use from $\frac{5}{16}$x2½ to ⅝x6 inches, and sold in kegs of 100, 112, 200 and 224 pounds. Wire tacks for carpets and upholsterers are sold in packages of from 1 to 24 ounces, and fence staples ¾ to 2 inches long.

Woven Wire.—Woven wire fencing consumes a large output of wire mills, and is made in "regular style," 22½ to 49 inches high, with from 7 to 11 bars; "special hog, horses and cattle," from 20 to 58 inches high; "special sheep and horse," from 26 to 35 inches high, and "special farm fence," from 45 to 49 inches high.

Hog Wire.—There are various other styles, one of which is known as "McMullen Diamond," for fencing in hogs, 2x4 and 3x6 and 4x8 mesh, and of heights varying from 18 to 72 inches. This fencing comes in rolls containing 20 and 40 rods. There is also made twisted ribbon fencing, barbed netting and horse fence wire, and two-and three-ply twisted galvanized barbless, sold on reels. Poultry netting is made from ¾-inch to 3-inch mesh, and from 12 to 72 inches wide, and from 14 to 20 gauge.

Comparative Summary of Wire Production.

	1880	1890	1860
Number of establishments	40	24	29
Capital invested	$4,230,071	$11,607,685	$4,242,173
Wage-earners	6,169	7,596	1,603
Wages paid	$1,982.731	$3,856,522	$859,645
Value of products	$10,836,605	$22,012,804	$9,421,238

The apparent decrease of $12,591,566 in the value of products reported under the classification "Wire," as shown in the above table, is explained by the fact that in 1890 all the establishments in which wire constituted the product of chief value were put under that class, but in 1900 only such establishments as purchased the wire rod or plate from which wire was manufactured were so included. The value of products reported for this industry in 1890 was, as seen above, $22,012,804, which was the value of the entire product manufactured in wire mills proper and in iron and steel works. In 1900 the value of products of the industry "wire" was $9,421,238; the value of iron and steel wire manufactured by iron and steel establishments in which the raw material was iron ore or pig iron, or iron or steel ingots, blooms billets, etc., was $35,283,688, which, added to $9,421,238, makes the total value of wire manufactured in 1900, $44,704,926. It should be explained, however, that a considerable part of the wire reported by iron and steel establishments was not sold as such, but was re-manufactured by the same establishments into wire nails. Making due allowance for this, it can be stated with certainty that, instead of decreasing, the value of wire manufactured and sold as such during the census year exceeded considerably the value of that made and sold in 1890.

An Allied Industry.—Consideration of the wire industry is not complete except in connection with that of almost equal importance, the wire-work, rope and cable industry, as stated below:

Comparative Summary of Wire work, Rope and Cable Industry.

	1880	1890	1900
Number of establishments ..	305	569	597
Capital invested............	$3,681,893	$11,757.902	$16,374,629
Wage earners	4,459	6,954	9,255
Wages paid.................	$1,708,175	$3,085,591	$3,934,525
Value of products..........	$9,127,818	$15,552,857	$19,942,822

Wooden and Stamped Wares.

Stamping Machinery.—The devising of heavy machinery for the rapid stamping of thin metal into various shapes for domestic purposes has given rise to an industry of great importance. The primitive method for stamping metal into shape for domestic use was laborious, costly and unsatisfactory. With the production of cheap iron and steel and the urgent requirements of householders, inventors devised appliances for the rapid production of a vast variety of goods of which the modern kitchen furnishes the evidence. The raw material is reduced to its proper thickness by being passed through rolls until the requisite thickness is secured; it is then automatically cut into proper sizes and also automatically passed to the operators who place each piece in position to be stamped. This operation is conducted with great rapidity and in this way a vast variety of stamped goods are produced at a cost which places them within the reach of all.

Woodenware.—The method of production of woodenware is simpler and requires an entirely different class of machinery. By the aid of this machinery, bowls, platters, spoons, butter prints, plates and dishes are produced automatically at remarkable speed. These wares are in great request in households, dairies and in many other industries, and serve temporary purposes which make them of great value. The industry has declined in activity during the past few years, owing to the abundance of other facilities furnished by paper mills and paper-bag mills. Paper is now being used for a vastly increased variety of purposes in the domestic arts. Paper receptacles of almost endless variety are now being produced at a cost much less than that of wood and better serve the purpose.

Statistics.—The woodenware industry, not otherwise specified, which in 1880 engaged 287 plants, employing 5,033 workmen, has now fallen to 104 plants, employing 3,036 workmen. The products of these factories in 1880 amounted to $5,235,474, and in 1900, $3,585,542. The stamped-ware industry, on the contrary, has grown rapidly and is in a large measure also responsible for the decadence in the demand for woodenware. In 1880, 27 establishments were engaged in producing stamped ware; in 1900, 139. The number of workmen engaged in the former decade was 2,730; at the latter, 10,002, to whom wages were paid as follows: in 1880, $972,544; in 1900, $3,730,341, showing a growth of the industry in 20 years to have been almost fourfold. The value of the products in these years were, in 1880, $3,997,926; in 1900, $14,546,191.

Wood Preservation.

Tentative Methods.—Methods of wood preservation, more or less efficient, have been developed, which, while possessing valuable chemical merits, are devoid of value because they cannot be commercially applied. The preservation of wood has engaged the attention of chemists and others for many years, but even now there remains much more to be done than has yet been done to give the industry a permanent footing.

Progress Being Made.—The railroad requirements of the country, especially for ties, has for years stimulated inventors and others to find economic and rapid method for the preservation of timber, but as yet none of the processes presented have met with general approval. There are quite a number of wood-preserving plants in the United States which are doing a successful business and wherein processes are being improved, but for general commercial purposes the art has not yet reached a point where it meets all requirements.

Preserving Compositions.—Injections of various compositions are made under various processes, most of them involving drying and soaking, etc. All of them are ingenious and creditable to inventive enterprise. A method prevails in France consisting of the application of lime in a tank. One plan is to pile the planks in the tank and cover them with a layer of quicklime which is gradually slaked with water. In the kyanizing of timber it is sometimes immersed in a saturated solution of corrosive sublimate in a wooden tank and put together so that no metal of any kind can come in contact with the solution. The impregnating of wood while in a vacuum with a small solution of sulphate of iron, and afterward forcing into the timber a solution of sulphate of lime, is found efficient.

Other Methods.—Another method impregnates the timber thoroughly with a simple solution of soap mixed with an acid. A favorite solution used is zinc chloride. One method uses common salt in a chemically pure crystalline form which, in combination with alum, makes the timber incombustible. A process for preserving oak consists in boiling the wood in a solution of gallotanic acid. Posts and pier piles are rendered nearly indestructible by boring one or more holes, larger or smaller, in the center of the butt, or the whole length if desirable, then filling with boiling coal tar and closing the aperture with a long paper wedge well driven home. Posts thus preserved and the exterior surface dressed with resin varnish will last for centuries. Wood exposed to the air should not be dressed with coal tar but with Stockholm tar or resinous varnish. Wood is rendered extremely durable and weatherproof by covering it with hot linseed oil varnish, several coats being applied in succession after drying. The value of creosote as a wood preserver is generally recognized, but the direct injection requires great quantities of heavy oil and causes a dessication of the injected pores. The high boiling point of creosote does not permit its employment in vapor.

Room for Improvement.—All methods, while effective within certain limits, lack the essential feature of broad commercial value. These processes are readily applicable in small quantities of wood, but the commercial requirements of today, especially railroad track requirements, call for the preservation of timber on a larger scale than has yet been effected. Those who are now leading in the industry in this country feel confident that they are on the road to success.

Best Solutions.—The growing scarcity of timber, especially for railway ties, is creating much interest in the United States, and energetic efforts are being made with a fair show of commercial success to supply the want. Impregnation of various solutions under the action, generally of heat, or sometimes under the action of chemical solutions, is the prevailing method. There are as yet no definitely established or widely accepted formula as to the best solutions to use. Kilns of special construction are used in some localities in connection with facilities to apply the best chemical agents available, and railway managers are using more or less lumber so treated.

Comparative Summary of the Wood Preserving Industry.

	1880	1890	1900
Number of establishments...	2	4	21
Capital invested.............	$120,000	$262,718	$1,229,746
Wage-earners.....	36	80	478
Wages paid.	$14,717	$29,317	$205,105
Value of products...........	$101,110	$143,475	$2,395,748

Fire-Proofing.—It is to be noted that valuable processes have been worked out in fire-proofing lumber for construction purposes, as well as for shipbuilding purposes, which promise ultimate commercial success. Numerous public tests have been given within the past two or three years of non-inflammability of lumber in temporary construction, which demonstrate beyond peradventure that this characteristic can be imparted to lumber in a most satisfactory manner. However, the fact that insurance is cheaper than specially treated lumber will check its rapid introduction.

Wood-workers and Wood-working Machinery.

Tools of the Early Woodworkers.—The woodworker may be justly entitled to the distinction of being the earliest mechanic. The hammer and wedge, or what answered the same purpose, were perhaps his first tools. The saw was probably the next device, and, though spoken of in Scriptures and other ancient writings, nothing is known of its origin. Talus, the mythical originator of the first saw, is said to have formed it from the jawbone of a snake. Perdix, we are told, used the backbone of a fish. The saw of the early Grecian carpenters had a similar form to ours, and with it, according to ancient testimony, quite serviceable work was done. Saws were used in Germany as early as the fourteenth century, although there is scant information as to the material of which they were composed. It is written down in the old books that there was a sawmill at Breslau in 1427, where lumber was manufactured; one at Holstein in 1545, one at Lyons in 1555, one in Ratisbon in 1575, and one in Norway as far back as 1530. The first sawmill erected in Holland

Wood Working Industry.

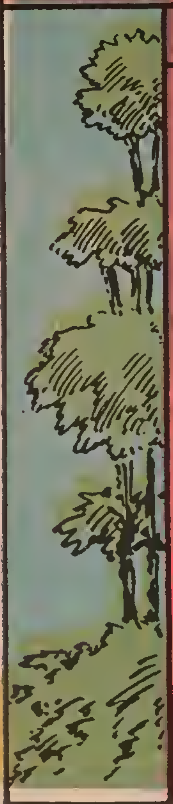
	No. of Establish.mts	Wage Earners	Wages Paid Dollars.	Value of Products Dollars.
Agricultural Implements.	715	46,582	22,450,880	101,207,428
Wheelwrighting & Blacksmithing.	51.771	36;193	17,974,261	85,791.630
Boxes, Packing.	896	22,034	7,827,955	38,216,384
Boxes, Cigar	315	4,609	1,439,599	5,856,915
Carpentering	21,315	123,985	71,049,737	316,101,758
Cooperage	2,146	22,938	9,200,303	40,576,462
Engraving Wood	145	337	206,537	616,166
Last Making.	65	1,131	649,654	1,879,742
Lumber & Timber	33,035	283,260	104,640,591	566,832,984
Planing Mill Products	4,204	73,627	32,685,210	168,343,003
Pumps, not Steam.	130	632	247,193	1,341,713
Refrigirators.	95	3,329	1,287.488	5,317,886
Shipbuilding.	1,116	46,781	24,839,163	74,578,158
Wheel Barrows	15	321	127,398	454,441
Wind mills.	68	2,045	940,474	4,354,312
Wood Turning & Carving.	1,171	11,569	4,375,345	14,338,503
Wooden Ware, not otherwise mentioned.	104	3,206.	1,073,303.	3,585,542.

Furniture and Upholstering Industry. Comparative View.

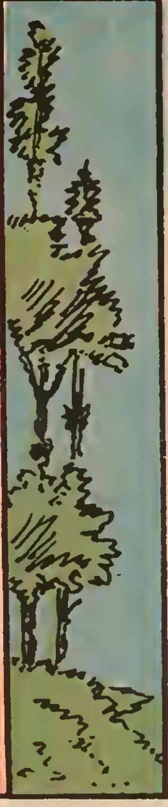
	1900	1890	1880
No. of Establishments.	7.972	5,973	6.008
Salaried Officials.	7,235	8,917	- - - -
Salaries Paid (Dollars)	7,042,172	7,976,186	- - - -
Wage Earners.	100,018	83,587	62,662
Wages Paid (Dollars)	46,638,810	40,816,566	25,048,414
Capital Invested (Dollars)	117,982,091	93,642,147	47,831,529
Cost of Materials (Dollars)	64,499,877	55,125,830	40,011.090
Value of Products (Dollars)	153,168,309	135,627,332	85,004,618

·WEIGHT OF SEASONED LUMBER·

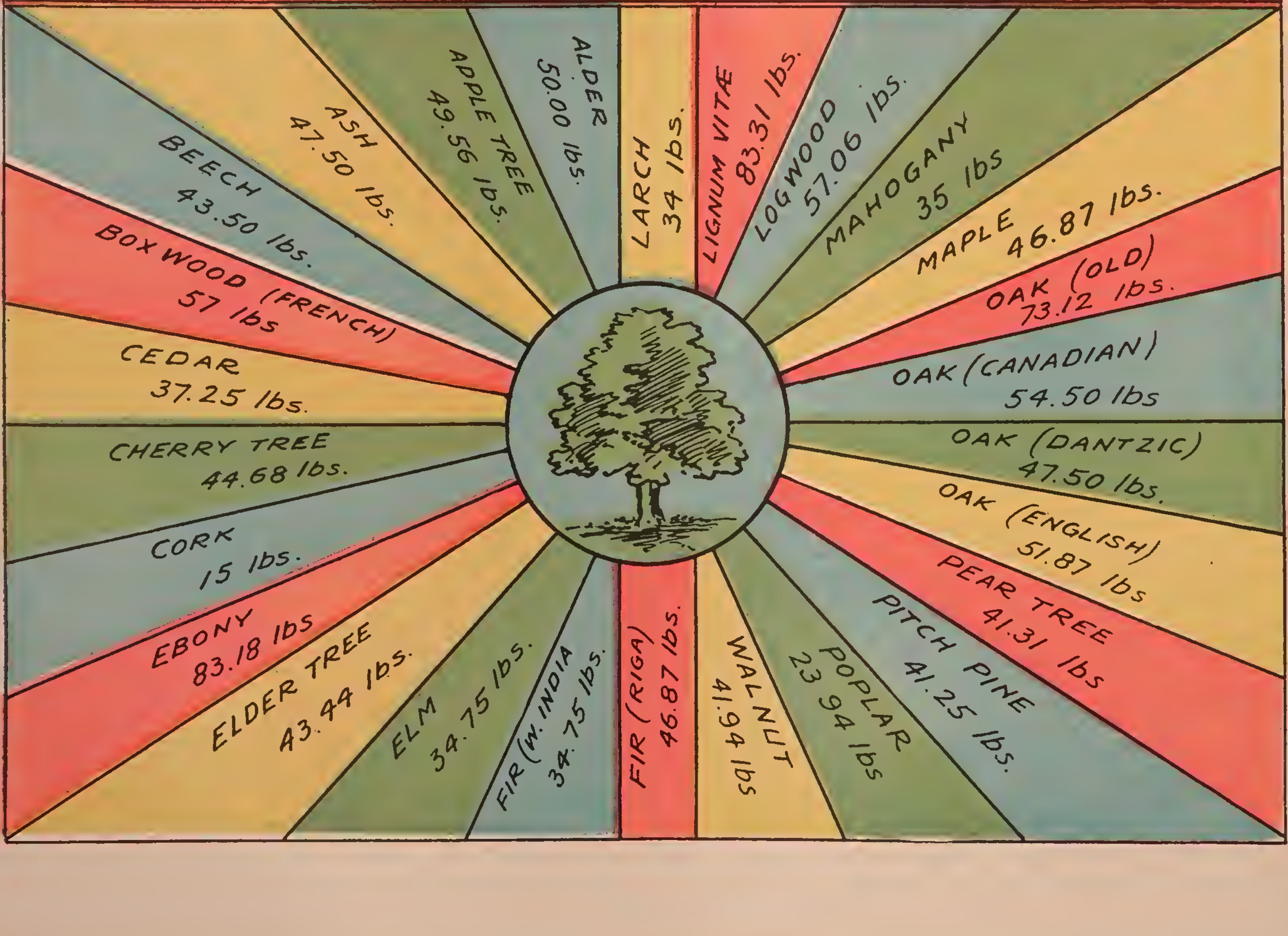
Seasoned Lumber of the Various kinds weighs as follows per 1,000 ft.



KINDS	POUNDS	KINDS	POUNDS
PITCH PINE	4,100	ELM	3,250
MAPLE	4,000	CHESTNUT	3,150
BEECH	4,000	RED PINE	3,080
DOGWOOD	3,950	POPLAR	3,050
HICKORY	3,950	BIRCH	2,975
LOCUST	3,800	CEDAR	2,930
CHERRY	3,700	YELLOW PINE	2,880
WALNUT	3,680	WHITE PINE	2,850
OAK	3,650	WILLOW	2,770
ASH	3,550	NORWAY SPRUCE	2,680
CYPRESS	3,400	HEMLOCK	2,360
		BUTTERNUT	1,950.



WEIGHT OF VARIOUS WOODS PER CUBIC FOOT.



ALDER	50.00 lbs.
APPLE TREE	49.56 lbs.
ASH	47.50 lbs.
BEECH	43.50 lbs.
BOX WOOD (FRENCH)	57 lbs
CEDAR	37.25 lbs.
CHERRY TREE	44.68 lbs.
CORK	15 lbs.
EBONY	83.18 lbs
ELDER TREE	43.44 lbs.
ELM	34.75 lbs.
FIR (W. INDIA	34.75 lbs.
FIR (RIGA)	46.87 lbs.
WALNUT	41.94 lbs
POPLAR	23 94 lbs
PITCH PINE	41.25 lbs.
PEAR TREE	41.31 lbs
OAK (ENGLISH)	51.87 lbs
OAK (DANTZIC)	47.50 lbs.
OAK (CANADIAN)	54.50 lbs
OAK (OLD)	73.12 lbs.
MAPLE	46.87 lbs.
MAHOGANY	35 lbs
LOGWOOD	57.06 lbs
LIGNUM VITÆ	83.31 lbs.
LARCH	34 lbs.

was at Saardan in 1596; one was in operation in Sweden in 1653.

Sawmills in England.—The first sawmill in England was erected by a Dutchman in 1663, near London. James Stansfield built a sawmill in 1768, which a mob tore down, as it invaded the "rights of labor" and deprived workmen of their previous opportunities of employment, as they believed. The circular saw was invented in Holland and introduced in England in 1777.

Saws in the Colonies.—The early colonists used saws, and they were highly prized and carefully used, because of the difficulty in obtaining them. For many years the only saws used were obtained from England, and their importation continued down until William Disston, a generation or so ago, produced saws of superior merit and serviceability. Since that time on, their importation fell off. In 1824 Robert Eastman, of Brunswick, Me., patented a circular saw which found ready and liberal acceptance. The business of saw making early assumed prominence, because of the urgent requirements for lumber.

Saws at International Exhibitions.—At the International Exposition in 1851 the exhibition of saws greatly stimulated the industry of manufacturing wood-working machinery. From that time on invention followed invention in quick succession, showing saws of increasing speed, efficiency and adaptability for all kinds of work. At succeeding international exhibitions the exhibitions of saws of all kinds constituted one of the most important features. The rapid development of wood-working machinery may be largely attributed to the ingenuity, inventiveness and enterprise of the maker of hand and circular and band saws.

Historical Reference. — Going back a little in the history of saws, we learn that the first attempt to supersede hand planing by machinery was made by Hatton in 1776; Bentham followed him, in 1791, with additional improvements; Bramah, in 1802, followed with decided innovations, but it was not until 1857 that decided progress was made upon broad commercial lines, that resulted in the production of planing and molding machines that would saw, plane, groove and tongue all at the same time, by a series of saws, planes and revolving chisels.

American Inventors.—American inventors early set their wits to work, driven by imperative necessities, and brought out machines with cutters working on a vertical axis with an improved reversing gear fitted to the traveling table. Factories for the turning out of wood-working machines sprang into existence, and marvelous mechanical progress was made. Machinery was built with surprising dispatch. Among some of the early makers were Fay, Farrar, Rogers and Whitney. Molding and shaping machines next followed. The first band saw was patented in France in 1815. Numerous improvements followed, until the present band saw was evolved. The jigger saw, with its flexible, self-adjusting bow, soon appeared, and it was successively improved. Richards introduced the reciprocating movement by attaching the saw arms to a continuously revolving wheel. One advantage of the band saw is that even in heavy timber the power required is small, the wear and tear moderate and the cut continuous. The lines of the design can easily be followed. Saws of very thin gauge are used in the production of architectural designs of great variety, and they can be worked out at an immense saving over older methods. These saws can be arranged to cut iron, bone, ivory, paper, cloth, leather and other material.

The Mortising Machine.—The invention of the mortising machine is generally attributed to Sir Samuel Bentham, who introduced it in 1793. A mortising augur for making square holes appeared in 1826. This was followed at Lowell, Mass., by a device for reversing mortising chisels by the foot. Another improvement varied the stroke of the chisel by link motion.

Tenoning Machines.—Tenoning machines, naturally, followed mortising machines. They are usually divided into three classes—machines with cutters running parallel or vertical, and working across or with the grain of the wood; machines which form the tenons by an arrangement of jaws, and machines in which the wood to be tenoned is held vertically and passed between circular cutter disks or gears.

Dovetail Jointing. — Dovetail jointing has brought out many inventions of great value. By suitable gearing the inclination of the saw disks is changed from vertical to horizontal, and are arranged to cut dovetails as required.

Special Machinery.—Veneer-cutting machines are of two kinds—sawing and slicing. Wheel and carriage-making machinery has been developed to a remarkable extent by numerous inventors who found strong inducements in the demand which sprang up for this specialized branch of invention. In the construction of the carriage wheel no less than twenty machines can be used to advantage. Cask-making machinery has also been developed to a high point of excellence and economy, in which direction inventors' ingenuity seems almost to have exhausted itself. In subsequently improved saw and cutter-sharpening machines the emery-wheel is mounted on a small steel spindle running in centers and fitted with a counterbalalced swinging carriage.

Supremacy of American Machinery.—The wood-working machinery industry has been developed in the United States to a completeness probably far beyond that of any other in the country in point of adaptability, speed of operation and economy. Machines are built not only to do almost everything that can be done by hand, but many things which human hands cannot do, excepting at an impracticable outlay of time and effort. The great wood-working machinery plants of the United States lead the world in the variety of machines produced, in their power, rapidity, efficiency and smoothness of workmanship. To the wood-working machinery makers is due a large share of the credit for the masterful accomplishments of American craftsmen in all those industries where machinery is used to fashion wood for further association with iron and steel.

The Scroll Saw.—Among the machines used by the wood-worker may be mentioned the scroll saw, which is made in great variety. It is built of iron and steel, with a table top of narrow strips of hard wood, and is mounted on an iron pedestal; its shifter and brake are operated by the foot, and is adjustable for belts running in any direction. The tension is evenly graduated on some of these machines; some tight and loose pulleys are 6 inches in diameter by 2½ inches face, and make 900 revolutions per minute.

Panel Planers.—Panel planers, used by car builders, sash and door, cabinet, pattern and cigar-box makers, will plane from one-sixteenth of an inch to 8 inches in thickness, and as short as 4 inchus, without clipping the ends of the work. The feed has various changes. The tight and loose pulleys on some machines are 10 inches in diameter, and make 900 revolutions per minute.

Cutting-Off Saw.—Another valuable machine is a swing cutting-off saw, which is very rigid, will not admit of any tension, and makes 550 revolutions per minute for 16-inch saws. Pulleys 9 inches in diameter, with 4-inch face, are often used. The panel-raiser is an important adjunct of the wood-working shop for raising panels of any style, width or thickness. The heads may be inclined to any angle and adjusted to and from the work without disturbing the angle; both table and guide are adjustable. A horizontal boring machine for light boring is an indispensable machine, and has a sliding table and pin-stop to regulate the depth to be bored.

Horizontal Boring Machines.—Then there are horizontal boring machines with treadles, which are much used in agricultural, wagon and furniture shops. In this machine the work to be bored remains stationary on the table, while the traversing steel spindle is moved up to it by means of a jointed treadle. The table can be raised or lowered and pivoted for boring at any desired upward or downward angle. It has gauge slides and a spacing rod, and a collar regulates the depths to be bored.

The Wood Lathe.—The wood lathe is an important feature of the wood shop. It consists of a head and tail stock, tool stand, three tees, face plate, etc. The molder is a very important, complicated and wonderful piece of machinery, and is made in various sizes. One molder much used is the 9-inch, which has a large range and capacity of work, and cuts up to 9 inches in width. It will dress on all four sides, flooring, sheathing, etc. The side arbors are adjusted vertically and laterally. It has four large feed-rolls, powerfully geared, and allows the table to drop eight inches. Another molder is a two-spindle upright, with a table 54 by 44 inches. Jointers or hand planers are also made in great variety. Band saws are of numerous designs and execute a great variety of work with wonderful celerity. With band saws great progress has been made in the wood-working craft and a variety and quality of work is turned out which, to the outsider, appears almost miraculous.

The Woodworker.—The remarkable progress of the wood-working industry is almost without parallel in the domain of handicrafts. Inventive talent has been lavish in this direction. The woodworkers of America lead the world in the quality of work done, as well as in volume per machine. The transition of crude material into a thousand forms of utility is done with almost miraculous celerity, and the mental and physical power of the workmen is kept on a tension to feed these voracious machines, which work with a fine mathematical exactness. American wood-working machinery has become known throughout the world, and its influence on the habits of the people of other lands is manifest.

The Wood-Working Industry.—Wood-working machinery has been improved up to a perfection that enables the wood-worker to furnish wood in almost any conceivable shape and for almost any desired purpose. This machinery represents the highest inventive talent, and performs work which to the outsider would seem almost beyond the power of machinery to perform. The products of wood-working shops enter into numerous industries, the implement and vehicle industries being large consumers of their output. The abundance of suitable wood stimulates production and enables manufacturers to select the most useful and fit kinds to meet the specific requirements to be subserved.

Comparative Summary of the Wood Turning and Carving Industry.

	1880	1890	1900
Number of establishments...	916	872	1,171
Capital invested............	$4,482,800	$7,825,688	$10,278,418
Wage-workers..............	7,240	7,402	11,569
Wages paid................	$2,585,578	$3,333,553	$4,375,345
Value of products...........	$8,426,817	$10,939,647	$18,338,503

These figures do not include all the products of wood-working establishments, because of the rules governing the Government in the collection of statistics, more or less production being separately included in the production of many plants not specially devoted to wood working.

Woolens and Wool Workers.

Ancient Weaving.—It is not generally known that weaving was practiced by prehistoric man. It was the first human necessity after securing sustenance; there are records showing that weaving in some form or other was understood and practiced by all peoples in all times. Wool was probably the first substance used. The Phœnicians, Assyrians and Egyptians were masters of the weaving craft and the ancient historians speak of the excellence of their work. The poems of Homer abound with descriptions of magnificent materials used for dress and tapestry hangings. The Romans possessed immense stores of most magnificent textiles of every description. Weaving was cultivated in Byzantium between the sixth and thirteenth centuries, and when silk was introduced into Europe in the reign of Justinian, an additional stimulus was given to weaving. More than two thousand years before Europeans had conceived of applying modern methods to the manufacture of textiles, the people of India understood and practiced hand spinning, weaving and dyeing.

In the Fourteenth Century. — The fourteenth century was the golden age of tapestry, and Flanders was the center of the industry, where perfect models of textile art were produced, rich in color, strong in decorative effect, graceful in drawing and composition and arranged with consummate skill.

First American Woolen Mills.—The first attempt at woolen goods was at Rowley, Mass., in 1643. The wool-card machinery devised by Amos Whittlemore in 1797, transformed the whole woolen industry. John Goulding and a few others revolutionized the methods in the carding department. The first cloth mill of any size was erected at Pittsfield, Mass., in 1812, by L. Pomeroy. Spinning jennies were introduced there in 1856, and a power loom for broadcloth was started in that town in 1826.

Woolen Manufacture at Philadelphia. — Early English settlers near Philadelphia in 1710 entered upon the production of woolen cloth and in Pennsylvania the output that year was 30,000 yards. The industry was largely carried on in households.

Inventions.—The series of inventions which led up to the marvelously ingenious looms of the present day originated with the invention of the fly-shuttle, so-called because of the rapidity of its motion, and which was invented by John Kay, of Bury, England, in 1733. Previous to Kay's time the shuttle was thrown by the weaver's hand across and through the warp threads from side to side of the web. His invention brought the plain hand loom practically into the form in which it continues at the present time, and it formed the basis of all modern textile machinery.

Stock Cards.—James Hargreaves adopted stock cards used in woolen manufacture to the carding of cotton. Then he invented the spinning jenny in 1767. Next, Arkwright contrived the spinning frame. The next, an epochal event, was the mule, completed by Samuel Crompton in 1775. In 1792, William Kelly, of Glasgow, applied power to the mule. Richard Roberts introduced the "cam shaft" by which all movements were regulated so as to succeed one another in proper order; in 1830 he patented a "quadrant" winding apparatus.

The Jacquard Loom.—The invention of the Jacquard loom was due to Joseph Marie Jacquard, of Lyons, France. He was asked by Napoleon to improve the then complicated loom, which he did to the lasting advantage of the textile industry. The fundamental conception of the Jacquard loom is to raise any number of separate leaches, corded leaches or heddles in any order and succession without any tying of harness. These machines are provided with 300, 400, 600, 900, or more hooks, and the whole function of the apparatus is to liberate these hooks in the order and to the extent necessary for the successive sheds.

The Carding Mill. — The carding mill is a branch of wool manufacture which is passing away. According to the fibre to be employed or the yarn to be produced, the spindles employed in wool manufacture are divided into three groups —woolen, worsted and cotton. The card-wool branch of wool manufacture has always been pre-eminent in the variety of its products and their adaptability to the needs of consumers. It is in the woolen mills that the great mass of goods required for the clothing of the people has been made. The products consist of broadcloths, doeskins, cassimeres, satinets, jeans, flannels, blankets, woolen and cotton mixed dress goods, linings, etc. The high-water mark in the production of the woolen goods branch of wool manufacture was reached in 1880 before worsted became popular.

Union Goods. — The production of union or mixed goods for men's wear shows a steady increase. Cotton warp goods follow. These goods are made on a cotton warp with a weft of wool or mixed wool or cotton, of which satinet is the type.

Scouring. — The production of woolen dress-goods has largely increased since 1890, while cotton warp products show a decline. Wool scouring establishments now number only twenty-five, most of them located near sources of supply. The operation consists of opening, burring, washing, scouring and dusting, and in these operations the wool loses from 20 to 85 per cent. of its weight. The average loss in domestic wools is about 60 per cent.

The industry of scouring and pulling wool is closely connected with wool production and wool manufacture. It is one of the minor industries, being represented in scouring by 25 establishments, in which, in 1900, 70,878,519 pounds of wool were scoured. In wool pulling there are 24 establishments engaged, the amount of wool pulled in 1900 being 28,663,806 pounds. All transactions in wool are based on the scoured pound. It is therefore of advantage to the manufacturer and dealer to have scouring plants at hand.

In Massachusetts, Connecticut and New Jersey 9 scouring plants are doing business, 6 in California, and the remaining scattered throughout the country.

Shoddy. — Shoddy is the fibre recovered from woolen, worsted or mixed rags, and is subdivided into shoddy, mungo, flocks and wool extract. The first two are recovered by machines known as "pickers" and "garnets." The pickers pick or tear the rags to pieces; and after that others open and prepare the material for carding. Flocks are produced generally from bits or pieces of all-wool rags, which are cut very short into a sort of powder by passing between the blades of a machine —a flock cutter. Flocks are mostly used to add substance and weight to woolen cloths, on the surface of which they are spread during the process of fulling, which incorporates them into the fibre by felting. They are also used to produce a woolly face on waterproof garments and for saddlery.

Wool Extract.—Wool extract is produced from rags of mixed fiber by a process of carbonization, which destroys all vegetable material and leaves only the wool, which is then reduced to fiber by mechanical operations. Besides the shoddy made by the shoddy mills, a large amount is made in woolen mills from rags and clippings. Shoddy is chiefly used in making low-grade satinets and heavy cotton-warp goods.

Material Used.—The total cost of material used in the manufacture of wool in the United States in 1900 was $181,159,127, of which $89,893,350 was foreign and domestic wool, with which was used 43,414,502 pounds of raw cotton, 3,048,146 pounds of mohair, 55,217,994 pounds of cotton yarn, 8,415,275 pounds of linen yarn, 70,873 pounds of silk yarn, 39,965,180 pounds yarn of jute, ramee, etc., and 71,496,508 pounds of shoddy.

Wool, Cotton and Shoddy.—The total of wool, cotton and shoddy used was 564,498,527 pounds, or about 7 pounds per individual. Of the total consumption of wool in 1900, 394,369,523 pounds, the domestic production amounted to 257,934,562 pounds and 136,434,961 pounds foreign.

Materials Used in Dyeing.—Some of the matet-erials used in dyeing wool are logwood, logwood extracts, camwood, fustic, dyewoods, cudbear, gambier, indigo, madder, orchil and its liquor, safflower and cochineal, besides oil of aniline and salts of aniline, alizarine and coal tar colors.

Three Classes.—The products of the wool manufacture are of three classes—goods dyed in the wool, in the yarn and piece-dyed goods.

The yarns used are classified woolen, worsted, merino, cotton, silk, spun silk, linen, jute and ramee.

Scoured Wool and Shoddy.—The consumption of scoured wool and shoddy increased from 255,000,496 pounds in 1890 to 310,128,960 pounds in 1900. Of this, in 1890, 56,826,475 pounds were shoddy and 71,496,508 pounds in 1900. The use of shoddy has made possible a greater supply of warm clothing than could have been obtained without it, while the mixture of cotton and cotton yarn with wool has made possible the production of soft, light-weight fabrics, well adapted for use where lightness, moderate warmth and low cost are desired. The people are better clad than before these combinations were devised.

Cotton-Warp Goods. — Cotton-warp goods are known as cassimeres, doeskins, tweeds, jeans, satinets, all of which have a cotton warp for their foundation. These goods are of low cost but durable.

Blankets.—Blankets are made of all grades, from the finest wool of firm texture, of heavy weight, highly gigged and soft as down, to the coarsest horse blankets, made with a cotton warp and of animal hair.

Shawls.—The shawl-manufacturing industry is declining under the mandate of fashion. The prevailing fashion for cloth and fur garments for ladies' use and for knitted shawls and similar wraps has so reduced the demand for woven shawls that the production has fallen from 7 to 1 in quantity during the past decade and in the ratio of 4 to 1 as to value.

Woolen Dress Goods. — The production of woolen dress goods has increased of late years, while cotton-warp products have declined. The manufacturers of the United States are successfully competing with those of England and France in meeting the American demand for these products by reason of the character, size and speed of machinery and the minimizing of hand labor. The opportunities for the expansion of the industry are regarded as favorable.

The following is a Comparative Summary of Wool Manufacturing Industry in the United States.

	1880	1890	1900
Number of establishments...	2,330	1,693	1,414
Capital invested.............	$143,512,278	$245,886,743	$310,179,749
Wage-earners.................	132,672	154,271	159,108
Wages paid.................	$40,687,612	$54,339,775	$57,933,817
Value of products..... ...	$238,686,511	$270,527,511	$296,990,484
Spindles in wool manufacture	2,111,973	2,793,147	3,511,099
Looms in wool manufacture.	57,297	69,658	74,190
Combing machines in wool manufacture.....	515	839	1,451
Cards in wool manufacture..	6,989	7,015	6,605
Consumption of wool in the United States (lbs.)........	427,184,530	548,167,332	483,865,236

Worsteds, and Worsted Workers.

First Worsted Worker.—It is claimed that John Marland, at Ballardville, Mass., in 1843, was the first who attempted to manufacture worsted goods in the United States; while he knew well how to produce delaines, both printed and piece-dyed, he did not succeed very well with worsteds in general.

Worsted Products.—The combined wool branch of the wool industry and its products are worsted cloths and suitings, worsted dress goods, upholstery goods and braids and worsted yarns used for carpet manufacture. The worsted mills are distinguished from the woolen mills by the initial processes to which the fibre is subjected.

Combing Machines.—The Pacific Mills, at Lancaster, Mass., imported from England six Lister combs in 1854. These, it is believed, were the first combing machines of this pattern set up in the United States. About this time the manufacture of dress goods was begun at Southbridge, Mass. Other mills soon entered upon the manufacture of all-wool worsted dress goods. About 1870 the manufacture of worsted cloths for men's wear was commenced in the United States, on a broad commercial scale.

The Noble Comb. — The worsted industry received a great impetus by the introduction of the Noble comb from England, a machine which made possible the use of short, fine wools for worsted yarns. The industry developed slowly by reason of cost of machinery, the unsuitable character of domestic wools and the heavy duty on suitable foreign wools. Despite these unfavorable conditions the industry took root. In twenty years from its start, viz.: in 1890, 17,591,087 square yards of worsted cloth were manufactured.

Men's Wear. — Men's wear goods are divided into two general classes, woolens and worsteds, which are further subdivided into all-wool, cotton-warp and cotton-mixed goods. These same divisions and subdivisions exist in dress fabrics for women's wear.

The most important division in value, if not in quality of the worsted industry, is the production of cloth for men's wear. The manufacture of worsted cloth was followed by a very heavy demand for this material. The cost of the necessary machinery, the unsuitable character of our domestic wools, the heavy duty on suitable foreign wools, all hampered the growth of the industry at home, but despite all, it grew rapidly and in 1900 the industry was represented by 186 establishments, with a capital of $132,168,110 and a production of $120,314,344.

Meeting Foreign Competition.—The manufacturers of the United States are competing successfully with those of England and France in meeting the demands of the American market. The average value per square yard of all dress goods of domestic production was estimated in 1900 at 29.07 cents and the foreign value of the imported dress goods was 22.76 cents per square yard.

Square Yards Produced in 1900.—In 1900 there were manufactured 103,496,097 square yards of worsted goods worth $26,739,595, and 41,094,590 square yards of woolen goods worth $14,869,034, or a total of 144,590,687 square yards worth $41,608,632. In addition there were produced 11,176,752 square yards of sacking, tricots, etc.

Worsted and Woolen Dress Goods.—The industry of worsted manufacture grew from four million dollars' worth in 1860 to $27,000,000 in 1900. In woolen dress goods the products included all manner of cotton-warp, wool-weft dress goods, sackings, tricots, and opera flannels, the total of dress fabrics in 1900 being 155,767,439 square yards, valued at $45,278,216.

The preference shown this class of fabrics soon led to the development of the industry on a large scale. The combing machine was rapidly perfected and enabled it to comb wool of short staples. The crossing of the merino sheep with those of English blood furnished an enormous supply and which enabled the mills to supply themselves with raw material.

Braids.—Braids are made from both woolen and worsted yarns, but mostly from the latter. They are used for bindings and trimmings. This industry was established in 1861. The manufacture of plushes and pile fabrics has developed quite rapidly under an enormous domestic demand.

Growth.—Many woolen and worsted mills mix cotton in the production of cloth, and improved machinery has reduced cost of production somewhat, but it is becoming more and more difficult for novices to engage in the business with success.

Comparative Summary of the Worsted Goods Industry.

	1880	1890	1900
Number of establishments	76	143	186
Capital invested	$20,374,043	$68,085,116	$132,168,110
Wage-earners	18,803	42,978	57,008
Wages paid	$5,683,027	$14,944,996	$20,092,738
Value of products	$33,549,942	$79,194,652	$120,314,344
Number of spindles	240,118	755,180	1,371,026
Number of looms	14,441	19,095	26,372
Number of combing machines	288	673	1,194

The Yeast Industry.

The yeast industry has attained an importance within a few years which justifies attention, especially in its relation to the great brewing industry. The cultivation of hops has been stimulated to a remarkable degree by the demands for material, and in different sections of the country large communities find constant employment in the cultivation of hops.

Yeast may be defined as a yellowish viscid substance deposited from beer or which rises to the surface of saccharine substance solution during the process of fermentation. Under the microscope it appears as granular matter, made up of heaps or strings of cells, each cell having an average diameter of one three-thousandths of an inch. This cell is a thin walled sack or bag and contains a protoplasm. Yeast is used in the production of alcohol from sugar, each molecule of sugar breaking up into alcohol. Its value is destroyed when heated above a temperature of 40 degrees. Grape juice and other vegetable juices under suitable temperature develop yeast cells, which is probably due to the presence of spores in the atmosphere. Yeast is useful and in fact essential in the production of wine from grape juice and other juices in the manufacture of beer and in the preparation of distilled spirits. Beer yeast acts as a stimulant and antiseptic when applied externally, and it has been profitably used as a poultice in many instances. It has been administered internally. Common yeast drained and pressed till nearly dry can be kept for several months, and is known as German yeast. Another yeast known as patent yeast is collected from a wort of malt and hop.

When yeast is washed with alcohol, dried at a low temperature and mixed with a little starch, it retains the power of setting up alcoholic fermentation for a long time.

Preservation of Yeast.—For domestic purposes yeast can be preserved by filling the thick portion of it into a champagne bottle, pouring on to the top of it about half an inch in thickness of oil. The bottle should then be covered with a piece of bladder, perforated by a pin to prevent explosion. This yeast will remain pure a long time in a cool place. So also it can be preserved if mixed to about one-eighth of its volume with clear glycerine. Another method to preserve yeast is to carefully wash the raw yeast with cold water, afterwards press the water out, and where possible still further concentrate it by means of a centrifugal apparatus.

Secrets and Mysteries of Mechanics and Tradesmen.

How to Weld Copper.—The materials used are soda phosphate and boracic acid, 358 parts and 124 parts respectively; at a dull red heat, apply the powder; when cherry red, hammer with a wooden hammer. The surfaces to be joined must be chemically clean so that a fusible phosphate of copper will be formed.

Fluxes in Welding.—A trade secret worth knowing is as follows: Take 6 ounces of common salt, 1 ounce black oxide of manganese, 2 ounces copperas, 1 ounce saltpeter, 1 ounce prussiate of potash; pulverize and mix with 3 pounds welding sand.

Waterproof Whitewash.—Sometimes a waterproof whitewash is required, but few are able to make it. Mix the powder from 3 parts of silicious rock, 3 parts broken marble and sandstone, 2 parts burned porcelain clay with 2 parts freshly slaked lime still warm. This forms a wash that becomes hard as stone. After drying, apply water freely and it then becomes waterproof.

Solders—How They Are Made.—Soft spelter is made of 1 part copper, 1 zinc; hard spelter, 2 parts copper, 1 zinc. Silver solder for brass and iron, silver 1, brass 1. Plumbers' coarse solder, 1 part tin, 3 lead; plumbers' sealed solder, tin 1, lead 2; tinners' solder, tin 1½, lead 1; hard solder for copper, brass and iron, copper 2, zinc 1. Silver solder for jewelers, silver 19, copper 1, brass 1; silver soldering for plating, silver 2, brass 1. Silver solder for silver, brass and iron, silver 1, brass 1. Gold solder, gold 12, silver 2, copper 4; bismuth solder, lead 4, tin 4, bismuth 1.

A Valuable Soldering Liquid.—Cut zinc into small pieces, dissolve in hydrochloric acid, add one-fourth part of the solution of ammonia, dilute with water. Dissolve in 12 parts of water, 1½ parts of glycerine and 1½ parts lactic acid.

Soldering Paste.—Make a syrup of starch paste with a solution of chloride of tin.

To Ebonize Wood.—Two fluids are necessary. Obtain a concentrated solution of logwood, add a a little alum. The other is obtained by digesting iron filings in vinegar. After dipping the wood in the first fluid, hot, let it dry and then treat it with the second fluid. Sponge with a solution of aniline chlorhydrate in water to which copper chloride is added. When dry apply solution of potassium bichromate.

How to Prevent Boiler Incrustations.—The following are the latest remedies devised to prevent boiler incrustations:

Twelve parts salt, 2½ caustic soda, one-eighth extract of oak bark, one-half potash.

Potatoes one-fiftieth the weight of water are said to prevent scale. Muriate of ammonia has a similar effect. Coating of 3 parts black lead, 18 tallow, applied hot to the inside of a boiler every few weeks, prevents scale.

Mahogany or oak sawdust, if used cautiously, is good. Slippery elm bark is also used. Paraffine oil has worked well in locomotive boilers and in marine boilers; a very thin wash of Portland cement works well.

To Harden Steel on the Outside.—Mechanics often have occasion to harden steel on the outside, keeping the inside soft. Not every one knows how to do this. Take 3 parts each of borax and potassium nitrate, 10 parts yellow prussiate of potash and 1 part lead acetate; grind fine and mix thoroughly. When the steel is heated to red heat, sprinkle the powder, return to the fire until the proper color is reached, then cool in rain water.

Cements to Fasten Rubber to Wood and Metal.—This cement is prepared by a solution of shellac in ammonia. Soak pulverized gum shellac in 10 times its weight of strong ammonia, which, after three or four weeks assumes liquid form. This softens the rubber and it then becomes hard and impermeable to gases and fluids.

Cementing Iron to Wood.—Mechanics often wish they knew how to do this. In a recess in the wood drop a small quantity of a strong solution of sal ammoniac, which causes the iron to rust; the rusting process constitutes the holding feature.

To Harden Steel.—Mechanics frequently need to harden steel and do not know how to proceed. Here is one method. To 1 pound prussiate potash add 3 pounds common salt, 2 ounces borax and 2 ounces cyanide potash. When hot, put the steel in the mixture and let it remain until cool, then plunge into water until cold. This prevents the steel from cracking or warping.

To Prevent Cracks in Metal Extending.—The usual way is to bore a hole where the rent ends, but if the right spot is not struck the crack passes beyond. A good way to find the right place to bore, is to moisten the cracked surface with petroleum, wipe and rub with chalk. The oil that has penetrated into the crack exudes and thus indicates where the crack has stopped.

How to Make a Cheap and Good Paint.—Three hundred parts clean white sand, 40 parts precipitated chalk, 50 parts resin, 4 parts linseed oil, mixed and boiled; add 1 part oxide of copper and 1 part sulphuric acid; dilute with linseed oil. This paint dries rapidly, but protects wood well.

Welding by Electricity.—The Thompson process is best known. Recent developments have resulted in the welding of materials heretofore supposed to be beyond the reach of welding. By the Thompson electrical process, copper can be welded to brass, to wrought iron, to German silver, to gold and to silver; brass to cast iron; tin to zinc, to brass; brass to German silver, to cast iron; tin to zinc, to brass; wrought iron to cast iron, to cast steel, to mild steel, to tool steel; gold to silver, to platinum; silver to platinum; wrought iron to nickel, to brass, to crescent steel. By the Thompson process different combinations can be made which are entirely impossible by ordinary methods.

Welding Cast Steel.—There are many methods in use, but one of the best is to roll in marble dust after heating the two pieces to be welded, then well hammer.

Welding Steel to Cast Iron.—The secret is to heat the steel to a cherry red, then apply borax to the surface, heat the parts to a welding heat, apply strong pressure, but do not hammer.

What Will Weld Cast Steel.—Grind 15 parts of borax, 1½ parts sal ammoniac, fuse until the scum goes; pour and cool, then grind fine. Dip the steel to be welded when heated to a bright yellow in this powder, then heat up to former heat, and hammer.

Cement for Brass Joints.—Melt 20 parts brass filing, 2 parts guttapercha and 4 parts caoutchouc.

To Cement Glass to Brass.—Work up any desired quantity of resin soap with half as much plaster of Paris.

To Cement Iron to Stone.—Some European workmen have devised a cement for this purpose which they make by melting resin in brick dust, which has to be very fine and sifted. The melted putty is poured in the space in the hole around the iron.

Cement for Mending China.—Boil slices of skim-milk cheese, wash in cold water, then work it well in warm water and then work quicklime into it thoroughly. This product will join earthenware and even marble and stone.

Cement to Stop Cracks in Glass Vessels.—Dissolve casein in a solution of borax. Take strips of hog's or bullock's bladder. Soak them in this solution, paste along the cracks and dry by a gentle heat.

Chinese Cement.—The secret of making this remarkable cement has been guarded for centuries. It has wonderful waterproof qualities. Three parts of fresh beaten blood and four parts slaked lime, with a little alum, makes a pasty mass all ready for use. It makes pasteboard as strong as wood. It is considerably used on the public buildings in China.

Chinese glue is made by dissolving shellac covered with strong liquid ammonia. The solution must be well shaken.

Coppersmiths' Cement.—This excellent cement is made by mixing powdered quicklime with bullock's blood, but it must be used at once.

To Mend Crockeryware.—A ready and simple method is to mix lime and white of eggs. It hardens rapidly, therefore very little should be made at a time.

Davy's Cement.—Mix well 4 parts common pitch with 4 parts guttapercha in an iron vessel. Keep it under water.

Glass Cement.—Dissolve 10 parts (or less) of pure dry gelatine in 100 parts of water; add 10 per cent of a concentrated solution of bichromate of potash. Keep the liquid in the dark.

Glass may be cemented to brass by boiling 3 parts of resin with 1 part caustic soda and 5 parts water, and mixing this with one-half its weight of plaster of Paris.

Glass may be cemented to iron by soaking fine white glue or gelatine a few hours in water, pour off the surplus add one-foruth the bulk of molasses. This should be gently heated until thoroughly mixed.

Glass may be united to metal by a mixture of gum and calomel. Add a little water to some gum arabic, and after twelve hours add enough calomel to make the composition sticky. The very best gum must be used.

Household Cement.—A very useful cement may be made of alum and plaster of Paris, well mixed in water.

Hydraulic Cement.—It is frequently necessary to make this cement on short notice. In linseed oil use 63 parts burnt brick and 7 parts litharge. The surfaces to be cemented must be wet.

Iron Cements.—There are many. Here is a good and simple one. Take equal parts of sulphur and white lead and a little borax, and mix thoroughly. Wet the parts to be cemented with strong sulphuric acid and insert a thin layer between the pieces of iron. It takes five or six days to unite the parts.

Jannin's Cement.—This cement is used for moulding objects of delicate and fine lines. It is made of yellow oxide of lead, with glycerine, which vary in proportion. Under gentle heat, this cement sets in a few minutes.

Japanese cement may be made with powdered rice and cold water, then gently stirring in hot water. After this, it must be boiled in an open vessel.

Porcelain Cement.—Plaster of Paris, added to a strong solution of alum, until it is creamy, unites glass, metal and porcelain firmly.

Cements for Pots and Pans.—Use sulphur and black lead, 2 parts to 1 respectively; melt the sulphur, add the lead, mix well, pour and cool, break up into small pieces; use these bits to patch, using a hot iron.

Cement for Roofs.—A good cement for roofs is made of 2 parts common pitch and 1 part guttapercha. Pour the cement hot; use a hot iron to make smooth joints.

A good rubber cement for attaching rubber material of any description is made by softening and dissolving shellac in 10 times its weight of water of ammonia.

Cement for Water and Steam Pipe.—Take 2 parts of sal ammoniac, 35 parts iron borings and 1 part sulphur and water. Make a paste and drive it into the joints with a chisel.

Shoemaker's Cement.—A good shoemaker's cement is made by dissolving guttapercha in chloroform until it is very pasty. The surfaces to which it is to be applied must be heated.

Steam Boiler Cement.—A first-class cement can be made by mixing 2 parts finely powdered litharge with 1 part fine sand and 1 part air slaked quicklime. It does not spoil. To use, mix a little of it with boiled linseed oil. Apply quickly, as it hardens soon. A good cement to stop up cracks and leaks in boilers is made of dried and powdered clay, 6 parts; iron filings, 1 part; made into a paste with boiled linseed oil.

Stickall.—Many a housewife wishes at times to know how to make stickall. Get some potassium silicate and make a solution. It is good to mend statuary.

Stonemason's Cement.—This cement mends broken stone and makes the stone as good as before. All that is needed is, say 10 pounds clean river sand, 1 pound litharge, a half pound quicklime and enough linseed oil to form a paste.

To Mend Stoves.—Joints in iron stoves can be mended with mica, wood ashes, carefully sifted, as much finely powdered clay and a little salt. Cracks can be closed by a cement made of finely pulverized iron, combined with liquid water glass.

Cement for Injured Trees.—This cement is made of 2 parts yellow ochre, 1 part sifted wood ashes, 10 parts white lead, 2 parts turpentine and linseed oil.

To Keep Brass Clean.—The best method in the world to clean brass is this: 4 parts nitric acid, 2 parts sulphuric acid in a stone jar. Dip in the acid, then in the water and rub with sawdust. Another method is to rub the surface of the metal with rotten stone and sweet oil, then rub with cotton-flannel and polish with soft leather.

To Clean Carpet.—Salt sprinkled on carpet will carry the dust along. Brooms occasionally wet with boiling suds last longer. Dip the broom in cold water. Shake off the drops and frequently repeat the process. In sweeping, always sweep the way of the pile. If swept against the pile it pulls up the fibre and makes places for the dust to lodge.

To Clean Clocks and Watches.—Into a quart of water, with 1 teaspoonful of liquid ammonia, scrape a little common soap. Plunge the clock or watch movements and allow them to remain twenty to thirty minutes. Wipe dry as possible. Polish with brush and powder.

To Clean Black Cloth.—An ounce of bicarbonate of ammonia dissolved in a quart of warm water, makes the requisite solution. Use a flannel or black cloth, then clean with clear water, dry and iron and brush in direction of fibre.

To Restore Color to Cloth.—Ammonia neutralizes the effects of acid. Follow this by application of chloroform. The use of chloroform is very little understood.

To Clean Diamonds.—Use soap and water with a little ammonia with a soft brush. Then dry in fine boxwood sawdust.

To Clean Engravings.—Pare away the edges of a stale loaf cut in half, rub the loaf circularly over the engraving, gently and evenly. This removes the most apparent marks.

To Purify Feathers.—Let a gallon of water containing 1 pound quicklime stand quite a while, then pour off the clear liquid and pour this over the feathers in a tub, having enough liquid for the purpose. Stir until the feathers sink. After three or four days, drain in a sieve, then wash and rinse in clear water; dry on a net, shaking occasionally; the dry feathers will fall through. Then beat the dust out. This entire process consumes in all about three weeks.

Hints to Painters.—The wasteage in paint brushes in many factories and shops would presuppose some lack of familiarity with the proper treatment of brushes. One rule is, burn some turpentine in a shallow dish, until hot, then smother. Rinse the brushes in this turpentine, and grease with a mixture of sweet oil and tallow. If brushes have become hard, soak them twenty-four hours in raw linseed oil, and rinse out in hot turpentine, or wash in hot soda and water and soft soap.

Cleaning Paints.—Among the various rules for cleaning paints, may be mentioned one. Take 3 quarts water, 1 pound good brown soap, cut into bits, and 1 ounce pulverized borax. Let it simmer, but not boil. Use flannel cloth.

Another good way is to dissolve a half ounce glue and a little soft soap in a quart and a pint of warm water; scrub with an old whitewash brush; rinse well with clean water. Use a wash leather and let the surface dry itself.

A better way to remove paint than by scraping or burning is to use a solution of soda and quicklime in equal proportions. Dissolve the soda in water and add the lime. Apply the solution with a brush and finish with hot water. But before repainting, wash with vinegar or acid solution. A paste of soda and quicklime will remove any paint no matter how long on.

Another method worth knowing is to mix chloroform with a small quantity of spirits of ammonia to remove stains from dry paint.

Removal of Paints.—A good composition to remove paint from floors is made of quickstone lime slaked in water to which is added one-third the weight in pearlash. Let the mixture remain spread a half a day or so and the paint will then readily scrape off.

Chloroform is the best agent to remove paint stains from fabrics, but it is very necessary to know how to use it.

Olive oil or fresh butter softens stains of paint or varnish; they can be removed as grease spots are usually removed. After covering old paint stains this way, apply chloroform on cotton or woolen goods.

Chemical Methods for Sharpening Files.—First, remove all foreign material by boiling in strong soda and water, dip in a bath of nitric acid with water in the proportion of 1 to 4.

Old files can be re-sharpened by washing in warm potash water, then drying by heat to remove grease. The sharpening solution is made with 3 ounces powdered borax, 3 ounces blue vitriol in 1½ pints warm water, add 10 ounces sulphuric acid and one-half ounce vinegar. When the files are taken out, dry them and rub with olive oil.

To sharpen files, first remove dirt by washing in warm water containing a little potash, then wash in warm water again and dry. Next, to a pint of warm water, add 2 ounces blue vitriol, 2 ounces borax, mix well; turn the files over and over, then add 7 ounces sulphuric acid and one-fourth ounce vinegar; finally, after removal, wash in cold water, dry by heat, use olive oil and they are ready for use.

Fillers for Painters.—For hardwood, make a paste of cornstarch boiled in oil, to which a little Japan is added, reduced with turpentine. This is all right as it is for white oak. A little raw sienna is needed for chestnut or ash. It is necessary to use enough color to cover the starch. A brush and rags should be used and after 48 hours it is ready for rubbing down. Do the same again if an extra fine finish is desired.

Another composition for filler is a quart of boiled linseed oil, 1 quart turpentine, 5 pounds cornstarch, 1 quart Japan and 2 ounces calcined magnesia.

Cracks in Floors.—Cracks in floors may be filled by soaking old paper in a paste made of 1 pound flour in 3 quarts water, with a tablespoonful of alum, well boiled.

A good filler can be made of new tallow and plaster of Paris, well worked together with heat. It is improved with a coat of shellac and French polish.

Another good filler can be made of 3 parts by weight of pulverized starch, 3 parts heavy spar, 1 part siccative and some turpentine. Then rub across the grain of the wood. After good drying, rub and polish.

How to Put Out Fires.—Shut the doors to stop draft up the chimney and throw salt on the fire.

Another way is to use a pump provided for the purpose, in which the water is saturated with carbonic acid.

Most extinguishing methods call for mechanical appliances, such as hand pumps. A good composition to be used in a hand pump is 40 parts crude calcium chloride with 10 parts salt dissolved in 150 parts water.

A good fire extinguishing powder is made of 16 parts common salt, 12 parts sodium bicarbonate, 4 parts Glauber's salts, 4 parts calcium chloride and 4 parts sodium silicate.

Still another is 30 common salt, 30 sal ammoniac, 40 bicarbonate.

Fire-Proof Paints.—A good paint is made of 10 pounds finely powdered glass, 10 pounds pulverized porcelain, 5 pounds calcined lime and 15 pounds silicate of soda. Apply with brush. Let the first coat work in before applying second.

Zinc chloride and sodium silicate are much used, but the chloride volatilizes, and the other washes off. A better solution than this, and which is not much know is, 3 pounds alum and 1 pound copperas in a solution. Apply 2 coats and next add a solution of copperas, mixed with powdered clay.

Incombustible Paper.—A very good preparation not well known, for rendering paper incombustible, is formed of 8 pounds pure sulphate of ammonia, 3 pounds boracic acid, 1¾ pounds borax and 100 pounds water. These proportions can be varied.

Fire-Proofing Wood.—Wood can be rendered partially fire-proof by successive whitewashings.

A wash composed of lime, salt and fine sand or wood ashes renders shingle roofs less liable to burn.

Fire-Proofing Shingles.—Builders who care to go to the trouble can fire-proof their shingles by dissolving 10 pounds sulphate of zinc, 10 pounds alum, 4 pounds caustic potash, 4 pounds manganic oxide and adding 4 pounds sulphuric acid in a half barrel of hot water.

Other Protectors.—Common whitewash well washed into well-dried wood renders it practically fire-proof.

A very efficient composition may be made of 1½ pounds borax, 1 pound sulphate manganese in 10 pounds water. Still another is a mixture of sulphate of ammonium and sulphate of lime, in no definite proportions.

Fire-Proof Paper.—A fire-proof paper can be made of 2 pounds vegetable fibre, 4 pounds asbestos and 1 pound alum, finely separated and intimately mixed. The proportions may be varied.

A fire-proof ink may be made with 10 parts dry platinum chloride, 30 parts oil of lavender, 30 parts Chinese ink and 2 parts gum arabic in 130 parts water.

Glazes.—A secret process for glazing earthenware, which is better than lead glazes, is to take 50 parts silicate of soda, 8 parts powdered quartz, 12 parts Meudon chalk and 10 parts borax.

Tobacco pipes can be glazed by a saturated solution of lead acetate in hot water.

Glues.—Glues lose strength in remeltings. They are strongest when applied hot. The strength of a beech joint across the grain is 2,000 pounds per square inch, and 1,000 pounds with the grain; maple, 1,400 across grain, 900 with the grain; oak, 1,700 pounds across, 600 with; elm, 1,400 and 1,100, respectively.

Compound glue is best made of flour mixed with white of egg, isinglass and some yeast well beaten, and thinned with gum water.

Cracking of Glue.—Cracking of glue is prevented by adding a little chloride of calcium, which attracts moisture. This glue adheres to glass.

A fire-proof glue is made by boiling quicklime in linseed oil.

Glass to Wood.—Glue for joining glass to wood is made by adding fine wood ashes when the glue is hot.

A little finely powdered brick dust will harden glue.

Where very strong glue is wanted, dissolve isinglass in water, strain through coarse linen, add alcohol.

Leather to Iron.—To glue leather to iron, paint the iron with white lead or lampblack, cover with glue that is made by soaking it in water, dissolved in vinegar, to which is added one-third its weight of white pine turpentine. The purpose of the vinegar is to make it of the proper consistency. Spread on hot and press the leather on quickly.

Some English mechanics have a secret process for making this glue. They boil for several hours 50 parts glue with 8 parts nitric acid in 130 parts water.

A very fine glue, not much known, is made by dissolving 1 part finely broken glue in 5 parts saccharate of lime.

A good liquid glue made without acid is as follows: Take 2 ounces alcohol, 1 pint rain water, 2 ounces dry white lead, 8 ounces best white glue.

Those mechanics who desire a liquid paste from starch and acid can make it this way: Put 2 or 3 pounds potato starch in 3 pounds water and add one-eighth pound pure nitric acid. After 48 hours' occasional stirring, boil, dilute with water and filter through a cloth.

A glue known as marine glue deserves to be much better known than it is. Take 4 parts shellac and 2 parts India rubber and dissolve in crude benzine, with heat.

A moisture-proof glue is made by dissolving 8 ounces of glue in a little less than a quart of skim milk, to which a little powdered lime could be added. Dry pocket glue is made from 12 parts glue and 6 parts sugar. Rice glue is made by mixing rice flour and water, boiling and stirring.

Tannic acid dissolved in water makes glue waterproof.

Hints for Workers in Iron and Steel.—If red-hot cast iron is quenched in cold water it becomes longer; wrought iron so treated becomes shorter.

Copper can be hardened by mixing 3 to 4 per cent oxide of manganese, when in a molten condition.

Cast iron can be hardened when heated to a cherry red and plunged in a preparation made of 1 pound concentrated sulphuric acid, 1 ounce nitric in 5 or 6 quarts of water.

Watch Drills.—Watch drills may be hardened by heating in a candle flame and plunging in candle grease.

Drills and cutting tools can be hardened in a solution of zinc in muriatic acid. The tools must be first sharpened, then heated to a cherry red, and held in the solution until cool. For tempered steel, use as lubricants oil or soap water. For glass, very hard steel and chilled iron, use turpentine.

To harden steel drills, heat to cherry red and plunge into sealing wax, repeatedly, until too cold to enter the wax.

To Harden Steel.—To harden steel, make a solution of 1 ounce cyanide potash, 1 ounce borax, 24 ounces common salt and 8 ounces prussiate potash. Reduce in a crucible; put the steel in the mixture until it gets hot, then plunge in cold water until cool.

A good fluid for hardening steel is made of powdered wood charcoal, glycerine, resins and linseed oil, which are thoroughly mixed and heated. Plunge the steel at cherry red.

The dangers to be avoided in hardening taps and dies are, twisting out of true and cracking.

Boiler Incrustation.—There is no end to remedies against incrustation. The objective point of all is, the formation of soluble compounds. In some plants 5 pounds of glycerine is used per ton of coal consumed. Among many tried remedies, a composition is used made of crystallized soda, dextrine, alum, sugar and potash, in prescribed proportions. For small, say five or ten horse-power boilers, a good composition is gamboge, 2 pounds; dextrine, 1 pound; potash, one-half pound, and sugar, alum and gum arabic to the same amount.

How to Tell Good Steel.—The better steel is, the more it is darkened with nitric acid. It shows a curved fracture when soft and a gray lustre when hard. At a bright red heat, good steel crumbles under the hammer, at a white heat breaks up; at medium heat it is drawn out. A blow of a hammer will drive a piece of good steel into cast iron; if poor it is crushed.

How Artificial Ivory is Made.—The bones of sheep and goats are macerated in a solution of chloride of lime, washed and dried, then, with scraps of hide, dissolved in a boiler, by steam into which a small percentage of alum is introduced. When a fluid mass is formed, coloring matter is added, then strained, cooled and spread on canvas and dried on frames in the air. It is then hardened in an alum bath.

To Make Kalsomine.—Any handy mechanic can make his own kalsomine and of any desired hue. The basic method is to soak say one pound of white glue ten or twelve hours, then dissolve in boiling water, then add 10, 15 or 20 pounds of Paris white, diluting it to the desired consistency.

As to tints, a little Prussian blue gives a soft azure tint, burnt umber, a brown tint, lavender a light blue.

Imitation Leather.—A gelatinous compound is formed of leather waste and caoutchouc, which is converted into homogeneous material and then treated with ammoniacal liquor. The caoutchouc gives elasticity and insolubility.

Another mixture consists of 32 parts gelatine and 10 part glycerine, to which coloring matter is added. It is rendered flexible in linseed oil. This substance is spread hot on cloth and then treated with saline solutions, or mixed with the composition before it is spread. The last operations are varnishing, bronzing or gilting.

Patent Leather Gloss.—The gloss of patent leather may be preserved by making and applying a mixture of melted wax, with oil of turpentine, olive oil and lard.

Preservation of Leather.—Leather can be preserved by melting equal parts of mutton fat and linseed oil with 10 per cent of Venice turpentine. An ounce of solid paraffine and a few drops of sweet oil in a pint of light naphtha, is good for leather on soles. Castor oil is the best leather preservative, but copal varnish is the best for the soles. Linseed oil rots.

Care of Harness.—Those who have the care of harness should put a little glycerine in the oil or fat used on harness.

Lubricants.—Mechanics frequently are disappointed in the manner lubricants act. It may be well to lay down a few principles and facts.

For light bearings at high speeds, the best lubricant is that which will remain in its place; also which has the greatest adhesiveness; also which leaves a minimum of residue.

Sperm oil is the best to give body to mineral oils.

Mineral oils rank first, sperm second, neatsfoot third, lard oil fourth. For heavy machinery, animal oils suit better than mineral oils on account of lack of body in the latter.

Oil of mustard, with a little petroleum or fish oil, is used where there is much friction.

Paint for Iron Surfaces.—Painters called upon to furnish a good paint for iron can make it by using 10 pounds wood tar, 1¼ pounds lampblack, and 5 or 6 quarts turpentine. After heating the tar to boiling, turpentine is added when partially cooled, mixed with the black. The consistency is determined by the amount of turpentine used.

Iron Paint.—An iron paint not much known is composed of pulverized iron and linseed oil and is good where the iron is much exposed to the weather.

Where changes of temperature are frequent, linseed oil varnish and amber varnish should be mixed with the paint for the first two coats.

To Harden Paper.—Very hard paper can be made by the following secret process: The pulp is subjected to the action of chloride of zinc, then subjected to a strong pressure, which makes it hard as wood and tough as leather. This material can be easily colored, and can be used to cover floors, make shoes, whip handles, and mountings for various purposes. Paper plunged unsized into a solution of chloride, acquires the same characteristics.

Luminous Paper.—Luminous paper is made by a process from a mixture of 80 parts pulp, 20 parts phosphorescent powder, 2 parts gelatine, 2 parts potassium bichromate and 20 parts water.

Papier-Mache.—Papier-maché is made of old paper ground into pulp with lime water and a little starch. This product is pressed, coated with linseed oil, baked and varnished. It is sometimes mixed with clay or chalk. To make it water-proof, sulphate of iron, quicklime or glue are used or white of egg. Borax and phosphate of soda make it incombustible.

Paperhanger's Paste.—Wheat or rye flour beaten perfectly smooth in cold water, brought to a boil under constant stirring, to which should be added a little creosote or carbolic acid, makes a good paste for paperhangers.

Plaster of Paris.—Plaster of Paris is gypsum from which the water of crystallization has been expelled.

The polish on plastic figures is produced by immersion in melted paraffine.

Plaster casts are hardened by a hot solution of borax or alum applied with a brush, followed by a hot saturated solution of chloride of barium and soap water.

Floor Paste.—Good plaster flooring can be made by a secret process used in France, in which 6 parts of plaster are mixed with 1 part finely sifted, freshly slaked white lime. After drying, the floor should be gone over with sulphate of iron or zinc.

A good substitute for plaster of Paris is made of 5 pounds linseed oil, 5 pounds glue and 10 pounds whiting, thoroughly heated and mixed.

How to Polish Substances.—Brass is polished with various substances. Rottenstone and sweet oil are used, rubbed dry with flannel and polished with leather. Tarnish is removed from brass with a solution of oxalic acid. A weak solution of ammonia in water makes a good wash. Rouge on a buff moistened with alcohol polishes gold.

To clean iron, engineers should use tripoli, rottenstone or pulverized pumice stone with engine or kerosene oil. To polish steel, rub down with emery, moisten with alcohol or water and polish with Vienna lime, rouge or tin putty.

Pumice stone and putty powder polishes ivory.

Hints Concerning Rubber.—Mechanics who have to handle rubber and rubber articles are frequently at a loss how to act. A few suggestions will not be out of place.

To soften rubber hose, dip it in petroleum and expose to the air or in a water to which one-half its volume of ammonia has been added. If it is necessary to fasten rubber to metal, use a cement made by soaking pulverized gum shellac in ten times its weight of strong ammonia, but it takes upwards of a month to form this solution, without the use of hot water.

Mechanics are frequently annoyed by rubber articles getting brittle. This can all be overcome by immersing in water in which there is plenty ammonia. Then there is always trouble with tubing. The way to keep tubes elastic is to wash them at intervals in alkaline water. It always helps rubber hose to dip it in petroleum and then give it a hang-up rest.

Best Solvent.—The newest and best solvent for rubber is a mixture of methylated ether and petroleum spirits.

To Prevent or Remove Rust.—Rust is the ever-present foe of the mechanic. Here are a few remedies not as widely known as they deserve to be Caoutchouc oil is always reliable in preventing rust; also a solution of India rubber in benzine is an excellent coating for iron, steel and lead; apply with brush.

Rust on Steel Tools.—If mechanics use steel tools, all that is necessary to prevent rust is to put a lump of freshly burnt lime in the drawer where they are kept. Another protection is a solution of tannin, 2 parts; antimony chloride, 4 parts; crystallized iron, 4 parts, dissolved in 8 parts water.

Tools can be kept from rusting by smearing them with a mixture made of melted lard with a little camphor, to which enough graphite has been added to give it an iron color.

To Keep Tools Bright.—Most engineers are familiar with the mixture of soft soap and pearl ash, but these other compositions will be found good. Try melting slowly, 6 ounces lard and 1 ounce resin, reduced to right consistency with coal oil. To keep polished tools bright, use boiled linseed oil; this forms a protecting film. Most mechanics know Olmstead's varnish, but all who do, cannot make it. Just melt a couple ounces resin and mix thoroughly some fresh lard.

Whiting and linseed oil will prevent rust. So will lubricating petroleum. It is always imperative to clean the surface of the metals thoroughly.

Rust on Bolts.—Iron bolts inserted in wood can be prevented from rusting by a compound of grease and zinc filings. Vaseline is an excellent preservative.

To Prevent Underground Rusting.—One pound each of linseed oil, coal tar and sulphur, heated separately and then mixed and heated to 300° F., applied to the iron heated, will prevent underground rusting.

Rust on Screws.—Screws can be prevented from rusting by dipping them in a paste made of graphite and oil.

In some localities mechanics use a little slaked lime and soft soap, covering the immersed tools with water.

To Remove Rust.—Sweet oil well rubbed in, two days later rubbed with pulverized unslaked lime, removes rust.

Tools immersed in kerosene oil give up their rust. Barff's process consists in passing steam over iron heated to redness. This liberates the oxygen of the steam, which unites with the iron, forming a film of magnetic oxide.

Nickel Plate Rust.—Rust can be removed from nickel plated articles by covering the rust with oil or grease, and after standing a few days rubbing with a little ammonia.

To Mend Saws.—A mixture of brass, silver and copper filings in the proportion of 6, 60 and 3 parts, respectively, should be neatly brought in contact on an anvil with the broken edges, cover with powdered charcoal then, with a spirit lamp and blowpipe, melt the solder, and file.

The wire edge can be taken from a saw by passing a whetstone over the side of the teeth, but the saw must be set true.

To Straighten Band Saws.—Band saws often get crooked. The way to straighten is to keep the saw in the machine, and find the twists with a foot-long steel straight-edge; chalk the spots; hold a mallet opposite the marks and with a hammer knock the twists straight, with easy blows.

To Detect Sewer Gas.—Any bright mechanic can detect sewer gas by wrapping a suspected joint with a piece of muslin, moistened with a solution of acetate of lead. If gas is escaping, the muslin is blackened. The usual way is to apply a candle, but this is dangerous. Another way is to make a sticky paste of dark soap and water. If gas is escaping, bubbles will show.

To Restore Lustre to Silk.—Women could make old silk look like new by grating potatoes in soft water, shaking well and let stand a day and night, then sponge with the carefully poured-off liquid.

To Whiten Silver.—Dip the articles in a mixture of 8 parts powdered charcoal and 2 parts nitre, well mixed with water. The work is thoroughly dried under heat, then cooled and boiled in a solution of bisulphate of potash. This operation is repeated, the articles are then washed in soda and water and dried in warm boxwood sawdust.

Varnishers and Varnishing.—Few painters feel sure of how varnish will act. It is a most annoying flirt, that tries the patience and tests the skill of the mechanic. Quality of varnish is determined by qickness in drying, hardness of coating, toughness of film, gloss and durability. It is a solution of resin in alcohol or turpentine. Each varnish manufacturer has or supposes he has his own secret. A brilliant varnish for iron, stone or wood, not much known, is made of ivory black and common shellac varnish. Ordinary coal tar varnish practically answers the same purpose.

A good body varnish is made in the proportion of 16 pounds copal with 4 gallons clarified oil, boiled until stringy and thinned with oil of turpentine. A good bookbinders' varnish is made by dissolving pale shellac in wood naphtha. A colorless varnish of great merit for bookbinders is made of 3 pounds shellac with 4 ounces crystallized carbonate of soda in 6 quarts of water, brought to boiling over a slow fire.

Electrical Varnish.—Electrical varnish may be made by dissolving orange shellac in 95 per cent alcohol, which may be colored to suit by a pigment.

To Produce Elastic Waterproof Compounds.—Combine the sap of mangrove with rubber in variable proportions. These compounds can be transformed into waterproof varnishes by the use of solvents and ingredients that are familiar to all workers in rubber goods.

To Waterproof Hats.—Paint the inside with Canada balsam, made hot, and make holes for ventilation to avoid baldness.

To Make Fire Hose Watertight.—Make a mixture of 100 parts glycerine and 3 parts carbolic acid, and draw the hose, perfectly cleaned and dried, through it.

To Waterproof Boots and Shoes.—Soak the soles with copal varnish and castor oil to the uppers.

To Waterproof Paper.—Immerse the sheets in solution of cuprous ammonia. Cardboard can be made by pressing several such sheets together.

To Clean Clocks.—The parts most frequently needing repair are the pivots of the upper pinions, pin wheel and pallet wheel. The best way of centring the arbor is to put a lantern runner in the throw. A good cleaning substance is made of rottenstone and oil applied thoroughly over every part. Always brush lengthwise of the plate. Finish with a clean brush wetted with turpentine, taking care not to bend the teeth or any other delicate parts. Carefully clean out the teeth of wheels, the leaves of the pinion and round the shoulders of the pivots as well as the holes in the plates. In repairing the escapement, reduce the friction by making the acting faces of the pallet very smooth. See that the pendulum is sound, that the spring is not cracked or crippled and that the suspension is sound.

In mending the average American clock, try the pinions to see if they are tight on the arbors. Use a little solder if necessary. Clean with chalk and water and then oil. If the pendulum wabbles, the spring is crippled or is loose in the stud or needs more freedom in the crutch. Where the pinions are worn, turn each wire round and add a small piece of solder to each; use rosin instead of salts for soldering. When the pallets are worn, the simplest way to move them is to get the centre of a Geneva hand and put behind the pallets. When brass holes get worn, open them and solder in a piece of hollow bass wire to fit the verge pin.

Watch Mending.—Watch repairing calls for the following implements: Work board, verge stake, pinion stake, bumping-up stake, pin vice, filling block, sliding tongs and chalk box. The rules to be followed in examining a watch are: See that the enamel dial is not cracked, that the hands fit properly, of right length and "free" in the dial holes; that the cannon pivot is free of glass, that the joint pins fit tight, that the bolt and spring are right, that the cap is clear of the case; next, push out the joint pin, see that the wheels and barrel are upright, that the wheels are free of each other, that the chain is free of the pillar and the stop stud, that the dial-feet are not in the way, that the dial or brass edge fits right, against the pillar plate; the dome must be at a right distance from all parts of the movement.

In replacing broken teeth it is not well to put more than one tooth in the same part of the wheel. Burnish pivots that show signs of rust or unevenness; in verge watches the mainspring must be adjusted to the fusee.

These are general rules for putting a watch together: Do not take up the same piece two or three times; hold each piece very lightly; keep it in the fingers as short a time as possible.

About Cements.—Every known cement belongs to one of four classifications, which is determined by its action. Cement drys by evaporation or congeals by cooling, or hardens by oxidation or "sets" by chemical changes. There are six things to remember about cements. The first is the necessity of effecting absolute contact, the great obstacle to which is air and dirt. Mechanics overlook the fact that all surfaces are covered with a thin film of adhering air and until this film is removed, absolute contact is impossible. This is accomplished by heat and pressure.

The second point is that as little cement as possible be used; third, cleanliness of surfaces. The fourth rule is that the surfaces to be cemented must be true at every point of contact; fifth, sufficient time must be allowed for drying or hardening; sixth, cement as near the color of the materials to be joined should be used.

Hints for Cleansing.—Ox gall removes stains from woolen goods. Benzine or oil of turpentine is used on delicate material. Stains caused by fruits and juices may be removed if the spots are rinsed, before they dry, in cold water with a few drops of liquor ammonia. Wine stains are removable by rinsing in cold water, then applying a weak solution of chloride of lime, then rinsing again.

Fresh ink stains yield to treatment with moistened cream of tartar, aided by a little friction. Most paint stains yield to oil of turpentine and oxygenated water, followed by dilute sulphuric acid. Old ink stains need protochloride of iron, then dilute oxalic acid.

Grease can be removed from stone steps or passages by pouring strong soda and water boiling hot over the spot, covering with a thin paste of fuller's earth overnight, repeating the process, if necessary.

For cleaning textile fabrics. Scouring with benzine is well known. Sugar and egg stains go under application of cold water and color is restored with use of acetic acid and alcohol in water.

To clean wall-paper, where people have rested their heads, make a cream of pipe clay and water and next day brush it off.

A Quick and Cheap Disinfectant.—The most reliable and potent disinfectant, said by some authorities to be superior to all others on infectious germs, is a gas made by mixing in a one-gallon stoneware vessel, a quart of water, 1¾ pounds commercial nitric acid and one-fourth pound copper turnings, which disinfects a room of 15 to 20 cubic yards, provided the crevices are stopped up.

A small-pox disinfectant is made of a solution of one-half pound copperas in 1 gallon of water.

Bleaching powder is a good disinfectant for urinals. Green vitriol dissolved in water is good for a short time. Commercial bleaching powder confined in a parchment bag lasts longest and is the best ordinary remedy.

A Good Fire Preventative.—Water saturated with alum is found to protect substances coated with it from ordinary fire heat.

Preserving Processes.—To restore printing on charred paper, pour collodion over it. In a few minutes it dries and covers the paper with a transparent coat.

Acid sulphite of lime added to beer, which it is desired to keep, serves the purpose; 1 to 1,000 parts.

The Chinese preserve oysters by plunging, only fat ones, in boiling water for an instant and drying them in the sun.

Sardines are preserved by plunging for 1 or 2 minutes under boiling oil in coppers.

There are two systems of preserving fruits and vegetables, one by the cold blast system and the other the hot air process. In the cold-blast system, the air is compressed in a chamber containing chloride of calcium, which is admitted into a chamber containing the substances to be treated. The materials are placed on galvanized iron wire screens and are subjected to a current of air heated to 240° F.

Another process subjects the vegetables to 70 pounds square inch steam pressure for a few minutes and then dried at 212° and next subjected to hydraulic pressure.

Potatoes are preserved by sprinkling the floor with quicklime, over which is spread a layer 4 or 5 inches thick of potatoes, adding lime and another layer and so on.

Still another process warms the potatoes and surrounds them with acetate of soda in powder to absorb their moisture.

A well-tested meat preserving process places the meat in a practically air-tight chamber through which air at 50° circulates.

In refrigerating cars, the dry air is cooled to 33°. Another method suspends meat in bags. Suspended in a temperature of 37°, produced by a steam fan, worked over ice-tanks.

To Preserve Posts and Piles.—Bore one or more holes, larger or smaller, near the centre of the butt, the whole length, if desirable, and fill with boiling coal tar and close up with a long taper wedge, so as to drive the antiseptic into the pores. Such posts dressed with resin varnish will last for an age. Wood exposed to the air should not be dressed with coal tar.

Several coats of hot linseed oil varnish, successively applied after each drying, renders wood extremely durable and weather-proof.

How to Stop Dry Rot.—Melt 24 ounces resin in 6 gallons train oil and, say, 6 rolls brimstone; when thin, add desired color, apply to wood, hot and thin, 2 coats.

Alloys and Their Uses.—Alloys of gold, silver and copper are superior in strength to the more fusible metals. In making alloys, the least fusible metal is melted first, except where the quantities are very small. The strength of an alloy depends on the order in which each part is melted. Stirring must be kept up to prevent the heavier metal sinking.

Cautionary Measures.—Workmen often melt too rapidly. They skim off the dross as rapidly as it rises to the surface, as long as the ladle is on the fire. They mistake the antimony in the mixture for the dross. To prevent oxidation, the surface of the melted metal should be covered with fine charcoal, as well as a little sal-ammoniac.

Resin is the best flux for alloys of copper and tin, and common resin soap for old brass. Black flux is made of 4 parts common bottle glass, 12 parts saltpetre and 14 parts crude tartar, with some calcined borax. Platinum, which cannot be melted at ordinary heat, is readily fused in combination with zinc, tin or arsenic. Nickel is hard to fuse by itself, but joins readily with copper to make German silver.

Before using, crucibles should be gradually heated. After pouring, the crucible should be returned to the furnace. There is no hard and fast rule for pouring, but the common-sense rule is to pour, when sufficiently fluid to produce distinct and sharp impressions in the moulds. Work is often spoiled by being poured too hot.

Lacquering.—A durable and perfect black varnish for iron and steel is made by boiling turpentine and sulphur. The turpentine evaporates and the sulphur unites with the iron. The art of lacquering originated in Japan in the year 724.

High Explosives.—Nitro-glycerine is made by mixing fuming nitric acid with twice its weight of the strongest sulphuric acid, in a vessel kept cool by water. When properly cooled, one-sixth its weight of glycerine is added, under constant stirring, and the undecomposed sulphuric acid being lighter than the nitro-glycerine, is syphoned off after both materials are poured into cold water. For safe transportation purposes, Nobel mixed with it 5 to 10 per cent wood spirits. Dynamite is made by mixing 75 per cent nitro-glycerine with 25 per cent of powdered sand.

Gunpowder.—Gunpowder is made of saltpetre, sulphur and charcoal in varying proportions. Refined saltpetre is required. Refined sulphur in rolls is reduced to an impalpable powder. The required quantities of sulphur and charcoal are thoroughly pulverized and mixed, after which the proper percentage of saltpetre is added. After thorough mixing, the powder is granulated, and the irregularly sized grains are sifted over two parchment sieves, which separates the larger grains from the smaller, they are then subjected to the glazing process and next dried gradually in a temperature which is increased from 66° to 130° or 140° in, perhaps, 4 hours time. It is then ready for use.

Gun Cotton.—The several varieties of gun cotton are formed by the action of nitric acid on cotton or lingnin. The most explosive are formed with the strong acids, sulphuric and nitric, mixed. The raw material is cleansed by boiling in an alkaline solution, then drying in a current of air and then boiling in clean water. It is again dried at 120°. The cotton in one-pound quantities is placed in a bath of the mixed acids, of 3 parts sulphuric and 1 part nitric. It cools in two or three days. The quantities are covered in earthenware jars, placed in cold water, where they are exposed to the acid for 48 hours. They are then plunged into a strong fall of cold water, wrung dry and placed in a stream of water for 48 hours. The cotton is washed and partly dried several times and then thoroughly dried at a temperature of 140°. This product is about three times as explosive as gunpowder.

To Drill Glass.—1. Use a steel-hardened drill wet with spirits of turpentine, saturated with camphor. The drill should be run rapidly and with a light feed. Holes up to three-sixteenth inch can be drilled as rapidly as cast steel.

2. When a large hole is to be bored, use a copper tube, fed with emery and turpentine, for which a vertical drilling machine is better than a lathe.

To Prevent Sticking.—Oilcloth or patent leather is prevented from sticking together by being separated in wrapping by paper impregnated with paraffine.

"Doctoring" Belting.—Slipping of belting can often be temporarily arrested by rubbing with a piece of beeswax on the inside of the belt, or on the pulleys. Slipping can often be prevented by tieing a piece of rubber around the belt pulley of the engine. Many mechanics forget to wash the belt before oiling and some make the mistake of oiling while it is stretched. Whiting is decidedly preferable to powdered resin.

To Bend Copper Tubes.—Fill them with lead or rosin and then bend as required, afterward melt out the material used.

In welding copper be extremely careful that charcoal does not touch the points to be welded, and as copper is softer than iron, it is better to cautiously use a wooden hammer.

Art and Science of Tempering.—All that has been learned and written does not exhaust this most vital subject. Tempering means many things, among them hardening, case-hardening, annealing, toughening and softening. Some of the latest conclusions of the most advanced metallurgists are herewith given.

1. Rapidity of cooling, which determines degree of hardening, depends on the way the piece is held in the hardening fluid; moving about in the cooling fluid cools unevenly. Hardening in running water has the same effect.

2 Soft steels are difficult to harden uniformly, because of uneven texture. Mechanics should remember that an article dipped is liable to crack, if it is drawn out before its temperature is reduced to that of the water.

3. The benefit of tempering is all lost if the steel is made too hot. Melted glass is sometimes used where hairsprings for watches are to be tempered. Cyanide of potash and salt are used in some places to temper taps, the object being to prevent loss of carbon.

4. Prussiate of potash makes iron almost as hard as steel, by being heated to redness and sprinkling with finely powdered potash; then plunging into cold water. The hardening is very shallow.

5. In some parts of Europe fine tools are made almost diamond-hard by being heated to whiteness and plunged into sealing wax, repeatedly.

Dipping in fused salt anneals without oxidation.

To Prevent Heating of Journal Boxes.—There is no end to methods. Three good methods are: Nine parts anthracite and 1 part oil dry tallow, or 8 parts lead to 2 parts cannel coal, or 8 parts ivory dust and 2 parts spermaceti.

To Restore Writing.—A strong solution of tannin applied carefully will bring out the letters.

How to Get Rid of Mildew.—Some soft soap, powdered starch, table salt and juice of lemon, applied to fabric, placed in the sun, and repeated, and then left out overnight will produce the result.

Counterfeiting English Oak Leather.—Two ounces of borax and oxalic acid in 2 quarts of water, applied to common hemlock or union sole, to which French chalk is afterwards applied, will make a perfect imitation of oak leather.

How Smokers are Deceived.—Cigarmakers make a solution of 6 parts sodium carbonate, 2 parts chlorinated lime and 16 parts hot water and spot the cigars with a pointed stick, out of this solution. The smokers imagine they are getting superior goods.

To Remove Damp from Cellars.—A pound of calcium chloride, placed in any convenient receptacle, draws the dampness. Instead of throwing the solution away, evaporate over a fire and use again.

To Prolong the Useful Life of Wood.—1. Chemists have within a comparatively short time elaborated a number of economical processes for the prolongation of the life of lumber, many of which have not become as well known as their merits deserve. French builders pile planks in a tank, which are covered with quicklime and are gradually slaked with water. Beechwood by this process becomes as valuable as oak for hammers and tools for iron work.

2. Timber can be kyanized by immersion in a solution of 1 pound of corrosive sublimate to 10 or 15 gallons of water, and which is best dissolved in tepid water. The kyanizing requires from one day to two or three weeks.

3. Another method consists of using a strong solution of sulphate of iron in a vacuum, after which the oxide of iron becomes insoluble by an injection of a solution of sulphate of lime.

4. Engineers who use large timbers can give them long life by covering them with a mixture made of sifted scales of iron, sea sand and powdered shell spread over a mixture of tar and pitch.

5. Rot is preventable by various washes, one is made of a mixture of a pound of corrosive sublimate to 16 or 20 gallons water, used hot. Another, as much sulphate of copper to 30 or 40 gallons water.

6. Ants and insects in wood are destroyed by corrosive sublimate or essential oils. Powdered borax drives out black ants. Petroleum is also good.

7. Carpenters should note the fact, though it is not practicable to use it, that planks laid in running water for, say two weeks, and stood endways in the sun and frequently turned will make the best flooring stuff. It is proof against worms and will never warp.

8. It is not the best thing to cap ends of timbers laid in mortar with melted pitch.

To Make Canvas Impervious.—Soak the canvas 30 hours in boiling water into which a decoction of oak bark has been introduced in the proportion of 1 to 15. It should be rinsed in running water and then dried.

To Make Hose Watertight.—Carbolic acid and glycerine, 1 part to 30, respectively, well brushed in, makes them watertight, but this process must be applied as often as they are used and they must be well dried.

Special Varnishes.—1. Varnishes in the mechanical arts have such a wide range of uses, that it is frequently found in shops that requirements arise for a particular quality that is not to be found ready made. A few hints, therefore, are in place, which may enable the mechanic to supply his specific wants. A good varnish for patterns is made of shellac and alcohol, 1 pound to a gallon, with enough lampblack to color. An oak varnish can be made of oil of turpentine and pale resin, 1 pound to a quart, respectively, colored to suit with lampblack.

2. German founders use a varnish for machinery made of Zanzibar and Manila copal, 1 pound each to 3 pounds shellac, heated by steam and stirred six hours, to which 100 parts or more potato spirits are added and then again heated to 190° F.

3. Melted paraffine used hot, is the best varnish for labels. Italian varnish is made by boiling Scio turpentine until it hardens, then pulverize it and dissolve it in oil of turpentine. A varnish for glass is made of tragacanth beaten to a froth in white of egg. Stand twenty-four hours. A flexible varnish is made of 2 ounces India rubber in 1 quart of water, dissolved with slow heat. Where a Japanned surface has been injured or scratched, a good varnish is copal varnish mixed with lampblack.

To Tin Castings Cold.—Small castings may be tinned cold by putting scraps of block tin in a solution of cream of tartar and boiling them in it.

To Make Holes in Steel.—Cover the steel with melted wax where the hole is to be made and let it cool. Then cut into the wax the size of the hole wanted, drop in nitric acid, and after it eats, wash off and add more drops until the perforation is made. This applies to thin steel.

To Frost Steel.—On the polished surface run dilute nitric acid and at the right time wash in running water.

Staining Various Materials.—1. There are upwards of twenty methods for making walnut stains, most of them complex. Among the simpler methods are these: Make a decoction of green walnut husks, dried, and boil in lye, or use dragon's blood and lampblack, mixed in wood alcohol

2. Dilute asphalt varnish, frequently applied, will do fairly well. Potassium permanganate dissolved in water, 1 part to 30, twice applied, makes a good stain. It should be washed and oiled and varnished.

3. What is called sixteenth century oak finish can be given to oak by staining with umber in thin shellac varnish.

4. A purple stain is given by boiling logwood in water, adding pearlash and indigo. This mixture must dissolve before using. German cabinetmakers get a good oak stain by using very strong coffee.

5. Bricks can be stained red by melting an ounce of glue in a gallon of water, and when hot, adding a chunk of alum, a half pound Venetian red and a pound of Spanish brown. A black color can be given by heating asphaltum to a fluid state and dip in the bricks, the surface having been moderately heated.

To Take Care of Shoes.—A good dressing for tan shoes is made of oil of turpentine. A solution of sulphate of iron and copperas in water takes away the shoe smell. To make shoe soles impervious to water rub on Stockholm tar. Another way is to warm the soles, then successively apply copal varnish after each heating.

The Art of Polishing.—Furniture oils are numerous, but the art is less understood than it should be. Among various oils may be mentioned these: Boiled linseed oil and alcohol shellac varnish, 1 to 2 parts, respectively, gives a good polish; beeswax to which a little alkanet root is added and melted and to which a little linseed oil and spirits of turpentine are after added, with subsequent straining, make a good polish. Brass may be polished by a very fine-cut file and emery cloth.

Invisible Ink.—Invisible ink can be made by mixing linseed oil and water of ammonia, 1 part to 20 in 100 parts of water. Shake before using. All invisible inks show on glazed papers; milk makes a good invisible ink and buttermilk still better. Writing by invisible ink is developed by the application of heat or chemical reagents. Nitrate of nickel and chloride of nickel when weak form an invisible ink, which becomes green by heating.

To Restore Tarnished Silver.—A warm solution of 1 part cyanide of potassium to 8 of water, which is extremely poisonous, will upon immersion render tarnished silver bright.

Of Secrets in General.—In olden times workshop secrets were most carefully guarded and every workshop had its own. In modern times the development of scientific methods and the education of workers in shops, schools, institutions and colleges have brushed away many former secrets by making them common property. While it would not be correct to say there are no longer strict secrets, it is correct to say that there are secret methods and appliances which are far more important as secrets than the old-time secret processes themselves. The custom of manufacturers in all lines to meet together in convention and otherwise and to unbosom thmselves with regard to every detail of manufacturing, certainly deprives shops of secrets as they were formerly understood. For all that, secrets when rightly interpreted control industrial processes as much and probably more than ever.

Patent Secrets.—This is particularly exemplified in many of the great iron and steel plants, where mechanical and electrical methods have been introduced and machinery patented unknown to the outside world, unknown even to competing interests. The introduction of electricity as a motive power has afforded inventive talent a wide field for originating methods of work which are valuable and produce economic results that stimulate competition. The general trend of mechanism is to better methods in the use of which results are achieved a thousand-fold more valuable to industry in general than the old-time secrets of individual mechanics. And yet there are in some few industries, secrets which are as rigidly preserved as three hundred years ago. These domains of secrecy are being steadily invaded and the time is not far remote when the entire world of industry will have within its reach all practical knowledge as to production.

New Kinds of Secrets.—At the same time there is rapidly developing a new factor in industry, which will create new conditions, namely the adoption of methods and systems of work. The industries are being revolutionized along these lines. Instead of a secret of manufacturing we have elaborate and complex and complete methods of manufacturing, involving the idea of magnitude on one hand and differentiation on the other. Work which in centuries past has been done by the single mechanic is now being divided up into numerous branches, each calling for specialized skill. The future progress which lies along these lines is vast. A wide field is opening up for the industries of the world in which America is taking the lead. It is teaching the mechanics of the world not to rely wholly on shop secrets, as they have been understood in the past, but on the wisdom and the absolute necessity of secrets of mightier significance—namely, method and appliance. It would be difficult to name a single industry in the world which is not being revolutionized and which is not being broadened out in accordance with the influence of these mightier agencies, which have swung into line in all of the industries.

Duty of Mechanics.—Knowledge is becoming common as it should be. The greater secrets of the twentieth century in industrial channels call for an aptitude, an energy, a comprehension and a devotion to each respective line of work which was not dreamed of when the industries of to-day were in their cradles. It, therefore, behooves every mechanic in every industry to address himself with the energy of enthusiasm to acquire somewhat of these mightier secrets that are dawning upon the world. The unending accumulation of patents are the secrets of the nineteenth and early twentieth centuries, but they are in a sense open secrets for the use of the world.

Secrets are Endless.—The energy of man is carrying him forward into the secrets of the universe with ever-increasing momentum. The universe itself is the greatest of all secrets. Its unfolding will occupy the attention, the study and energy of man for all time. For one secret that is known to-day there are a thousand to find out. The progress of society, the upbuilding of the mighty industries depend upon the unearthing of these secrets of nature and they will, year by year, be placed before the world for its best use.

World's Debt to Mechanics.—The world at large owes its progress to the mechanics; it is they who point the way to better things, better methods, and more abundant fruit of effort. That which to-day is a luxury will, through the skillful touch of the mechanic, become the necessity of to-morrow. The mechanics are the world's warriors, who are achieving victories under the canopy of peace, which spread plenty and bring happiness and fill the world with sunshine and joy, rather than with sorrow, horror and poverty which were the gifts of those in the past who attained the leadership of men. To-day the mechanics are the real leaders; without their thought and skill and toil and invention, civilization would be arrested and Progress would close her eyes.

Mechanical Education.—With the increase in the number of technical schools and manual training schools and universities where scientific study with reference to industrial development is systematically and comprehensively prosecuted, a higher level of practical knowledge and understanding is being reached. In these institutions the older secrets are being made common property and the newer secrets, which inventive talent and the understanding of nature's laws bring to light, are being gradually mastered for the further and far grander upbuilding of society.

AN EXPLANATION
OF
PRACTICAL ANATOMY
AND THE
PRINCIPLES of PHYSICAL CULTURE

BY

EUGEN SANDOW

The Elementary Principles of Scientific Body-Building, and a Guide to the Acquisition of Perfect Health, through Simple, Natural Exercise. : : : :

PHYSICAL CULTURE

BY EUGEN SANDOW

Physical Culture, pure and simple, is the development along natural lines of that wonderful combination of muscles with which the Creator has endowed mankind. It is the education of the body as contrasted with the education of the mind. To be more exact, physical culture is the science of developing and harmonizing the muscles of the body, internally and externally, by a conscious effort of the will power. How few have given any thought to the scientific development of their bodies! It is an astonishing fact that 90 per cent. of men and women die without taking up half the good gifts of life that lie within hands' reach. A well-developed body implies a well-developed brain, and for a full enjoyment of life both are absolutely necessary.

What is Physical Culture?

In beginning this series of talks I want to make it clearly understood that I do not propose by my system to produce a nation of athletes. To make a heavy-weight lifter, or a runner, or a wrestler, is to apply Physical Culture to weight-lifting, or running, or wrestling, as the case may be. What I desire is to turn out healthy men and women. Indeed the reader will find that the keynote of my system is Nature, and that the word "Strength," when used, refers rather to perfect robustness of constitution than to mere muscular power that permits of a man performing Herculean tasks. It is possible, for I have demonstrated it in my own person, for men to become naturally capable of achieving extraordinary feats of strength; but every man does not wish to devote his life to performing unusual feats. The deliverance of the Gospel of Strength—in other words, the teaching of Physical Culture—I regard as my life-work, and my aim is to teach men how they may arrive at that condition in which they will be best able to carry out their life's work, whatever it may be.

Value of Physical Culture.—I say whatever it may be, there is no department in life in which Physical Culture does not bear a part, and in which the physical culture man does not stand the best chance of ultimate success. And the secret lies in the fact that Physical Culture is all-round development. Nature abhors lopsidedness next to a vacuum. The lopsided article topples over, and the man who is partially developed is lopsided. One has but to glance round to find a dozen illustrations. Take the field of manual labor. One man is strong and handy with the spade; another is quick and sure-footed with the hod; a third has a true eye for building a wall. But it is the all-round man who rises to be foreman. The same rule applies in the commercial, the social and the scholastic worlds. And, lastly, Physical Culture plays no insignificant part in the moral realm.

Care of the Body.—Health is a divine gift, and the care of the body is a sacred duty, to neglect which is to sin. But while this may be termed a sin of omission, it is also true that a great many of the sins of commission are due to an unhealthy state of body and mind. For instance, a man who keeps his body in good condition, and his system in good tone, will feel less desire for intoxicating liquor, and less effect from what he does take, than the man who is careless about the state of his body. There can be no doubt, either, that one of the greatest elements in making for a pure mind and a lofty imagination is a pure, healthy body.

What Others Say.—I should just like to quote here the remarks of the Rev. Henry Howard, one of the ablest ministers in Australia. In a sermon preached while I was in Adelaide, Mr. Howard said: "Those of you who have seen Mr. Sandow perform know what a wonderful power he has of controlling his muscles. Now, there is a twofold advantage in that faculty. Firstly, there is the strengthening of the will-power. Though I do not take much notice of phrenology, I believe the phrenologists when they say that colonials lack power of concentration; that they like change, and do not care to be fettered down to a thing; that they are desultory in their studies and soon grow weary. If Sandow's method can help them, by concentrating the mind on the particular sets of muscles they wish to exercise, it will eliminate this weakness in the next generation or two, and have a lasting effect on the Australian race. The second advantage of the faculty of concentration is the development of muscle. The care of the body is a moral duty. All those wonderful powers stored up in our muscles are a sacred trust, which we are bound not only to guard from disgrace, but to definitely direct to the highest ends. It is more than a personal matter; it is a sacred duty owed to Society for us to bring ourselves to the highest degree of physical and mental efficiency." I might add that I fully concur with Mr. Howard's remarks. I believe that it is the Divine Will that we should make the most of our bodies, and it is by the aid of that power that we are enabled to attain a pitch of perfection.

History of Physical Culture.—A word as to the history of Physical Culture. The first nation known to have pursued Physical Culture systematically and individually was the Greek. With the Spartans, men, women and children exercised in the public parade ground, the children beginning their daily exercise as soon as they had gained the age of five. Every town in Greece had its gymnasium, and this was remarked as an infallible sign by which a Greek town might be recognized.

In Rome.—When Rome was at its highest and greatest, each Roman citizen exercised in the Field of Mars. The Emperors themselves joined in these sports, and Marius declared that he never missed a day at the Field of Mars. In the days of Rome's decline, the cult of the body degenerated with other studies, and these exercises became to the majority spectacular contests only. From that date Physical Culture almost died out in Europe, in spite of the attempts of Luther and Zwingli to restore it.

In Germany.—The next great name on the roll of Physical Culture is that of Ludwig Jahn. This great teacher introduced the German system, and established his turn anstalt, or gymnasia, first in Berlin, and then throughout the whole of Germany, in the days when Napoleon was overrunning Europe. So manifest were the advantages which this national interest in the development of the body produced in Germany that Louis Philippe introduced a French gymnastic system into the French army in 1844. But the French system was not in any way as thorough or scientific as the German.

In England.—Although the custom in England of engaging in out-door sports has made the English remarkable as a nation for their physique, yet, strangely enough, no attempt was made to introduce, and indeed no thoughts had been entertained of introducing, any such system of training until 1825. At this date, Clias was appointed teacher in the Royal Academy at Woolwich, working on the German system. Clias' teaching, however, did not go very far, and after the Crimean War a Royal Commission was appointed to inquire into the matter. The result of this was that Archibald MacLaren was appointed teacher, and, in 1861, took charge of the Military School at Aldershot. Shortly after this gymnasia were established in all military barracks. The movement rapidly spread from the army to civilians, and latterly was introduced to the public schools.

The Life Physical.

A Few Practical Hints and Suggestions as to the Care and Development of the Body.

The Advance of Physical Education.—Without doubt society is beginning to take a more commonsense view of physical life. If the advance in knowledge has brought with it fads and follies, it has at least added to the common stock of happiness and health. In coming years there can be but little doubt that the physical condition under which nations live will be as nearly perfect as possible. Homes will be made sanitary, every house will possess a bath and an abundant supply of water, every river will be kept pure, adulteration of food will be rendered impossible, the air will not be laden with impurities, and science will repair the evils which science has created.

The State and Physical Education.—It must be confessed that already many of the evil conditions under which physical life existed in the Middle Ages, for example, have passed away. The prevalence of skin diseases in those days was due to the infrequency with which people bathed or washed. In the present day there are few who are unable, if they are willing, to secure the daily bath. The education of the nation's youth is under State control, and during school life every citizen is now taught the ordinary laws of health. When the State realizes the power which it has for good, we can see enormous possibilities in the future. The State must soon realize that not only the mental and moral, but also the physical lives of its people are under its control, and that for those lives it is responsible. The day of national physical education must soon come, when every child from the age of five to fourteen will exercise daily under medical supervision. A movement in this direction has already been made in many schools by giving students facilities for admission to public baths. However, this effort is only local, and I might add that no school should be complete without a swimming pool and a set of showers. The facts are so plain that it is impossible to see the cause of delay; but, as I say, the day is near at hand. In many parts of the country teachers are doing as individuals what the State ought to organize, just as, fifty years ago, mental education was left to the discretion of the individual schoolmaster (with, indeed, the most excellent results in many cases, but with the general result that the nation as a whole was not properly educated).

A Rational Day.—I have often been asked to sketch out what I should prescribe as a healthy life for a man who works hard, either mentally or physically. A general description of a healthy habit of life under these conditions would be as follows: Early rising should be practiced summer and winter. This I believe to be conducive to both health and a good day's work. Upon arising, about twenty minutes' exercise, with or without apparatus, should be taken. This exercise should be honest work—the whole mind should be bent upon each movement, and you should leave off warm, if not perspiring, and happily tired for the time being. This exercise should conclude with the cold tub. However, a minute or so should elapse between the exercise and the cold bath, to let the heart become regular in action again. After the bath dry quickly and dress promptly. After an interval of rest, during which the morning papers, etc., may be read, private correspondence looked over, a short walk should be taken in the open air before breakfast. I believe in the substantial breakfast. It should be a most important meal. Plenty of time should be allowed, and no rushing for trains or street-cars should be indulged. In fact, I would recommend that every one walk at least a part of the distance to business, during which walk most of the problems of the day can be solved, thus leaving the mind free for detail work.

The lunch, in my opinion, should be light and nourishing. The ordinary business lunch is heavy and unwholesome. In the evening, when the day's labor is over, the day's worry should be forgotten. "Easy to say," you reply. Yes, and easy to do, if you stick to a healthy habit of living and regular business habits.

Part of the way home should be walked, also. The dinner which follows should consist of at most three courses. To my thinking, the greatest mistake of the day lies in the heavy dinner in vogue. The modern dinner, with its artificial stimulants and sauces, its heavy seasonings, its wines and liquors, is, perhaps, the most foolish of modern institutions. Hardly sufficient time elapses between one meal and the next to let the stomach empty itself, so that men and women are forced to torture the laden stomach into artificial and utterly unwholesome craving. Is it any wonder that at those hours when people draw their chairs together and discuss their pet diseases the majority invariably speak of their digestions? A safe rule to lay down is that one should never eat to the point of satiety, but should always arise from the table with the feeling that another dinner could be eaten. If one has been led to commit an indiscretion, then a few hours after dinner it may be worked off by exercising until the natural buoyancy and vigor are gained. Under normal conditions, however, after the meal a short walk should be taken, and then to bed. This I believe to be a rational habit of life for the business man.

Diet.—In regard to diet, I am no dietarian, but I consider that far too much meat is consumed in this country, much to the detriment of its citizens' health and digestion, and, if my medical friends speak true, much to the spread of cancer. The amount of food consumed is vastly in excess of what is required, entailing further labor upon the various excretory organs and poisoning the tissues with excess waste of products; for the surplus is not properly digested, but passes along the intestines a sour, fermenting mass. Some of the poisonous products are absorbed, so that we have headache and depression. The quantity of food taken should be smaller, the substance lighter, and more time allowed for mastication. Of course, if great physical exertion is daily made, then there must be a sufficient amount of food to balance the account. Without doubt, vegetarians have introduced many wholesome reforms, yet I am not in favor of a diet wholly vegetarian. Still, every one must acknowledge the benefits which vegetarianism has brought. To eat an apple or an orange after the morning bath is a very healthy habit, and is more generally practiced than people believe.

My Experience in Dieting and Training. — I have tried most of the various systems of training and dieting, and have come to regard them as fads —some harmful and some harmless, but none strikingly beneficial. I believe that nature is the best guide as to what we should eat and drink; and, provided that we do not eat or drink too much, I think one cannot go far wrong in taking those things which a healthy appetite and a natural inclination suggest. The danger lies not so much in the quality as in the quantity of the food and the manner of taking it. I would rather eat six times a day, a little at a time, than live on two hearty meals. But again I say each man is a law unto himself and must make his own experience his guide and eat in moderation. What is one man's food is another man's poison.

The Most Nourishing Foods. — Of course the most strengthening and nourishing foods are those which contain the most albumen. Milk, cheese and eggs contain large percentages of albumen, but the stomach cannot deal with more than a limited quantity of these foods without experiencing discomfort. Of recent years, however, the method of extracting albumen from milk — or rather buttermilk—has been discovered, and the extract has been put on the market under the name of *Plasmon*. This plasmon was discovered by an enterprising German chemist, and its use is spreading all over the world. As to its sustaining qualities I can bear personal testimony. I have lived on it for seven weeks, taking about eight teaspoonfuls a day dissolved in water, this being my only food during that period, and I was performing twice a day. It is prepared in various ways, being free from flavor and smell and perfectly soluble. It can be dissolved in water and made into soup, or added to other soups, or may be kept on the table and added dry. It can be dissolved in milk and then added to tea or coffee, and is now, I believe, made up in chocolate bars, beef extracts, biscuits and bread. Whenever I travel I carry some with me.

Other Suggesions.—The clothing should be sensible, night clothing not too heavy. The bedroom should be well ventilated, so that it does not smell stuffy in the morning, otherwise you will not awake refreshed and invigorated. As regards sleep, the hours should be as regular as possible. The old maxim, "Early to bed and early to rise," is literally and absolutely true in practice. Ten hours for youngsters and eight for adults I believe to be the correct proportion.

In these remarks I have endeavored to give as broad a view as possible of what I regard to be a healthy habit of life. Each reader has, of course, the limitations of circumstance, but, generally speaking, the above regime will enable one to cultivate and develop the life physical, on which are built the life mental and the life moral.

Exercise—Its Function and Field.

Primitive Man and Exercise.—Exercise—I am now speaking of general exercise as apart from systematic—is one of nature's necessities. The great law that function makes structure is no better exemplified than in the physical world. To primeval man exercise was a necessity. To obtain his food he had to hunt and kill it. Tribal warfare not only required him to be strong, but gave him the means of being so. Indeed, seldom could he partake of his food without active interference from his fellow-tribesmen. In this way the physically unfit went to the wall and only the healthier members survived. With the advance of civilization, however, the absolute necessity for physical strength departed, but with it came the danger which necessitates systematic education.

Modern Environment.—The sedentary life is full of pitfalls. Such is now the strain of mental competition that the body is too often neglected, and this neglect brings with it physical degeneration. Recreative exercise is now too rarely possible to the dweller in the great city. No one knows better than the city clerk or the harassed man of business that recreation in the open air will bring with it the health which is necessary to him in his daily vocation. The opportunities for this, however, are so few and time so limited that few can indulge in recreative exercise. Even walking—the king of all recreative exercises—demands patience and time for the man who has to travel many miles before he gets away from the blighted area of city dirt and smoke.

Systematic Exercise Adapted to All Classes.—It must be admitted that under present-day conditions of life there is only one form of exercise which can be practiced by all, from the weakest to the strongest, from the poorest to the richest, from the most occupied to the most leisured classes—that is, systematic exercises, which can be followed day in and day out in the smallest room or in the open air. Systematic exercise has these several advantages over general or recreative exercise: Its practice occupies comparatively little time. Each movement has a definite object, the result of which can be accurately calculated. By its means one secures general and well-balanced development, almost impossible in ordinary exercise, the tendency of which is to develop one part of the body at the expense of another, the will-power is strengthened and the internal organs share in the benefits obtained.

Will-Power in Exercise. — The contraction of the muscle is regulated by a series of nervous stimulations to the various muscle cells; the strength of these stimulations is increased by the use of the will-power. In fact, it is impossible to exaggerate the importance of will-power in systematic exercise. In recreative exercise the object is, or should be, to take away the influence of the brain on muscular contraction. In walking, for example, if you were to use will-power in the muscular contraction necessary for every step, you would barely be able to walk a hundred yards without suffering from great fatigue, while by making walking a pure mechanical exercise a large number of miles can be easily covered without any feeling of exhaustion. But in the one case you would develop the strength and size of the muscles involved, at the same time bringing them under the control of the will, while in the other case the muscular development would be very slow and the influence of the will over the contraction or coördination of muscles would not be increased. Therefore I say that the cardinal point in systematic exercise is the use of the will-power.

Function of Exercise.—The function of exercise is to give to the body, in any age and in either sex, the health, strength, habit and grace which nature originally intended it to have, but of which it has been deprived by the shackled conditions of civilized life. The object of systematic exercise is to bring this great possibility within the reach of all, so that in the shortest space of time, whatever the physical condition may be, whatever the weight of the individual's purse, these results can be obtained without undue demands upon the time of the pupil and without the slightest fear of overtaxing his strength. I think I can claim, without any egotism and with the full knowledge that I shall be backed up by my pupils all over the world, that the Sandow System exactly fulfills this function.

Field of Exercise.—As for the field of exercise, its field is the world. Wherever the human body exists exercise is as necessary as food or air. The weak it will make strong, the strong, stronger; at the same time it will give their bodies symmetry and grace, whilst improving the coördination of the muscular groups. It will better fit them for their daily toil, it will fill out their wasted limbs, strengthen the heart, deepen the lungs, and fortify them against disease; it will reanimate the tired and jaded nervous system, and bring back vitality and vigor to the exhausted brain.

How I Became a Strong Man.

Not Necessary to be Born Strong.—When the life-story of, say, a poet is being written, the author usually tells how at a very early age he developed signs of genius, and wrote rhymes almost as soon as he could talk. It would add to the picturesqueness of my story if I could recount wonderful tales of childish feats of strength; but, alas for picturesqueness! I must say that as a youngster I was anything but an infant Hercules.

My Early Life.—I was born at Königsberg, Prussia, in 1867, and, though extremely fond of sports and athletics at school, was not by any means robust. As a matter of fact, I was so delicate that in 1877 I was taken down to Italy by my father in the hope that the change would build up my constitution. The desired result of the trip was achieved, but hardly in the expected manner. It was not by strolling under the blue Italian skies in the ozone-laden breezes from off the Mediterranean Sea, but by spending every available moment in the art galleries and museums of the great cities, that I learned the secret of health and strength. The works of the old masters in sculpture and painting roused a thrill of half-envious admiration in me, and the more I studied them the more they fascinated me. Eventually I came home from Italy with the fixed determination that, if training could do it, I would become a strong man. Years passed, however, before I was able to accomplish my ambition. Then the idea struck me that there was something more than mere mechanical working of the muscles behind the perfectly-developed bodies I had seen. Such perfect development could not be reached by any amount of running, or lifting or fighting. These old Greeks and Romans must have possessed some secret of which we moderns knew nothing. Then I set to work to study anatomy and medicine. I obtained a thorough knowledge of the muscles and organs of the body, and, by dint of a great deal of time and thought and hard work, I devised a set of exercises which would treat all the four hundred muscles in turn, and so produce a harmonious result.

I Put In All My Will-Power.—Then the work began! Realizing that the brain governed the muscles, I brought the whole force of my will-power into the work, and kept at it day after day. The result was magical. I grew strong rapidly and surely, became a leader in various forms of athletics, and finally came to the conclusion that my life's work was to teach men the benefits—nay, the necessity—of Physical Culture.

How I Became Known.—Of course, one does not become known in a day, and I had to win my way first to the front rank, then to the foremost position, and finally into public recognition. When I had passed my twenty-first birthday I went to Amsterdam, and applied at all the theatres for an engagement. All I asked was 10 guilders—less than $5.00—per night; but there was no opening anywhere. At last I was pretty low in funds, and had to sit down and think out a scheme for obtaining an engagement. As I sat wondering, I caught sight of a machine that registered the amount a person could lift, and a notion struck me. That evening I engaged a cabman, and went round to all the weight-lifting machines in the city to "see how much I could lift." Well, I found I could lift more than the makers bargained for, and so I lifted the handles out of them all. It was a case of the tester tested.

My Amsterdam Experience.—Next day there was a tremendous hubbub, and inquiries were set on foot to find out what band of marauders had been wrecking the machines. My friend, the cabman, kept quiet, and nothing was discovered. The performance was repeated several nights later, and still there was no discovery of the supposed wreckers. However, the third time I succeeded in being discovered, but the porter who saw me at the machine was so amazed that he ran to the police station and brought a posse of constables to arrest me. Of course, I went along quietly. When I got to the station, I explained that I had paid the necessary coin into the machine, and was entitled to exercise my arms. Of course, they refused to believe that one man could be strong enough to break the machine, and sent for the chief officer. When he came along, he, too, was doubtful of my story; but when the strongest man at the station accepted my invitation to try his strength on me, the commissary was not only convinced, but became quite friendly, and I was released on my own recognizance.

The success of my advertising scheme was immediate and immense. A great crowd had gathered round the police station, and they accompanied me back to my hotel, and cheered me for a long time. News of the affair spread all over the town, and the "Paleis Vood Volksvlyt," which had refused me an engagement at 10 guilders a night, made an engagement with me to perform at a salary of 1,200 guilders a week.

From Amsterdam I went to England, then returned to the Continent, and, after spending a couple of not uneventful years, the greater part of them in Italy, I once more (in 1889) went back across the Channel, where I defeated Samson, and ever since then England has been my adopted country.

What My System Is.

As I mentioned before, I devoted some considerable time to the study of anatomy and medicine, and the result was that I grew to understand something of the close connection existing between brain and muscle. On this principle I founded my system, and years of experience have convinced me of its truth. I have, it is true, invented a series of exercising devices, but the secret of success in physical development lies not in the construction of the apparatus, nor in its regular use; it lies in the brain, which directs the exercises. It may be summed up in a brief sentence—It is not HOW MUCH you exercise, but HOW you exercise.

Description of My System.—The Sandow System is a form of physical education by means of which every part of the body is properly exercised, developed, and made healthy; the will-power increased; the various organs brought to and maintained in a healthy condition, and the individual made as nearly as possible physically perfect. It is not a question of learning to perform acrobatic feats with dexterity or of lifting heavy weights; and I make use of only the lightest weights, thus avoiding undue strain upon any part. As the physical needs of no two people are alike, I find it necessary in some cases to employ at the start the use of light dumbbells in others not. Exercise, however, without a judicious use of will-power (brain-power) is of little value. In some cases it is absolutely necessary to stimulate will-power by the use of dumbbells (see page 27). All depends upon the individual. The movements are simple, and may be learned in a very short time.

My system is divided into four groups:—

First Group.—The first group consists of exercises for the treatment of obesity, indigestion, constipation, liver and kidney troubles, and other complaints and weaknesses located in the region of the abdomen.

Second Group.—The second group consists of exercises principally for the development of the lungs and chest, thereby improving the circulation, strengthening the heart, restoring sleep, increasing the respiratory power, and giving that mobile chest which is associated only with sound and robust health, and which is also of so much value to those who study the art of singing. It is a notorious fact that the development of the lungs is too often left entirely to chance, when a few natural, healthy, and simple exercises, such as I prescribe, practiced regularly, would fit one out with lungs that will defy pulmonary or any other chest trouble.

Third Group.—The third group consists of exercises that will strengthen the great muscles that support the spine, the weakness of which is mainly the cause of curvature—a deformity so very prevalent among young girls, and which is apparently increasing in frequency. To correct this, gymnastics and other forms of recreation are often resorted to, which attempts at cure not infrequently bring about a worse state of affairs than before. Such cases require the most careful attention, and only such movements must be used as are contained in this particular group.

The above three groups are divided into numerous grades or series, so that, no matter what age or size, or what condition a pupil may be in on coming to me, the exercises can be adapted to his or her particular case.

Fourth Group.—The fourth group consists of series of exercises for the general development of the whole of the muscles and nervous system. Prescriptions from this group are only given to those whose health is what is usually described as robust; *i. e.,* those who know nothing of chest or stomach trouble, and who do not require work such as is set forth in groups 1, 2, 3. It is what I call my *body building or double-contraction* series. After a pupil has been made sound and healthy and the weak spots strengthened and all the previous ailments removed by the use of judiciously selected preliminary exercises, I begin to prescribe from this group for the purpose of building up the body, making the physique more beautiful, and maintaining the organs in a healthy condition, thus increasing the muscular and organic strength, improving the carriage, and increasing the symmetry of the body. It is from this group that I maintain my own strength and keep myself always fit.

It is said that there is nothing new under the sun, but this double contraction method of exercise I claim to be absolutely new and original, and hitherto unpublished by me. Even my many imitators have not had the opportunity of appropriating this, which, I maintain, is the secret of my excessive strength, and which I have hitherto zealously guarded; but for the strong and the robust I intend in the future to prescribe from this group.

The word "strength" is often wrongly construed. People speak loosely of not wishing to become "very strong"; but true strength means organic strength—in other words, health as well as muscular strength. We cannot have the one without the other, if we exercise honestly. True strength is the most desirable of all ends.

How—Not How Much.—I wish strongly to impress upon the delicate, and also the robust, the desirability of progress by degrees. Remember it is how you exercise, not how much you do. Many before beginning my system have been so weak that doctors have thought little of the probability of saving their lives, yet to-day they are among the strongest. They have progressed *gradually.* I have always been careful not to give them too much to do, always adapting the exercise to their own individual requirements. Pupils must not be discouraged because after the first few days' exercise they feel stiff. The so-called stiffness of a muscle after exercise is nothing more or less than a silent though effective indication of its torpid and sickly condition. There is no muscle in the entire anatomy of the human body which can safely be allowed to degenerate into a condition where a few minutes of reasonable active exercise will cause stiffness. Remember a degenerate muscle (organ) in any part of the body is a constant menace to health; and, whenever reasonable exercise produces stiffness or lameness, you should at once regard this as a warning which cannot be safely disregarded if you would be strong and well.

After Benefits of the Sandow System.—"What," it is asked, "are the general benefits of the Sandow System of Physical Culture?" I answer: "The benefits are not confined merely to the visible muscular development, important as this may be: the inner organs of the body also share them. The liver and kidneys are kept in good order, the heart and nerves are strengthened, the brain and nervous energy are braced up. The child should be taught concerning how to maintain a healthy body, and it is only through a series of exercises that this education can be given. By its aid the whole body may be kept in a perfectly healthy condition. Pupils who have followed my system often write me, testifying not only to their increased strength, but to their general health. *They feel as well and strong—as they look.*"

Practical Anatomy.

Muscular Anatomy.—Since it is of the utmost importance that the student of physical culture shall have a good idea of the location and function of the various muscles, I first shall set forth the muscular anatomy of the body, calling attention to the principal muscles, giving a detailed description of their functions and their value and relation to the rest of the body. The accompanying charts show only the muscular coating of the body. The human body is given as it actually is, with the muscles shaded in. This will enable the student to identify the various muscles of his own body and tell which muscles require the most attention. In short it will enable one to understand his own physical make-up perfectly.

Importance of the Muscular System.—This muscular coating is the real protection and mainstay of the body, for upon its good or bad condition depends the strength or weakness of the vital organs and the consequent health or disease of the individual. The muscles may be regarded as the business agents of the human structure, for upon them depend the activity and utility of life itself. Considering that even the gentlest act of breathing and the ordinary every-day duties of the stomach, liver, etc., in fact every activity of the body, rests upon this intricate system of muscular fibre, it will be readily recognized that it is of the utmost importance to maintain this part of the human organism in a healthy and vigorous condition.

The Object of Physical Culture.—However, to lay stress upon muscular development by the faithful practice of carefully prepared exercises is not for an instant to recommend or encourage the development of abnormal bunches of fibre. Muscle is to be sought only as a means to an end, not as an end in itself. The true end is a perfect body, internally and externally, for the primary object of physical culture is to promote a healthy development of every tissue of the body. It is not alone well-developed biceps that count in the battle of life, but sound lungs, a strong heart and a good digestive system are far more important. Neither would I underestimate the value of muscular development, for physical force and bodily strength have had and always will have their weight in the world's affairs.

Voluntary and Involuntary Muscles.—The muscles depicted in these charts are voluntary, *i. e.*, those that are brought into action as the direct result of the will-power. But dependent upon these for health and strength, and closely linked to them, are the muscular walls and lining of the internal organs. These are known as involuntary muscles, because no action of the will-power has any direct influence over them. Few, indeed, recognize the importance of these great muscle groups. It is a fact that liver, stomach, heart, lung and bowel troubles are due to muscles improperly nourished and exercised. While immediate pains may be relieved temporarily by medicines taken internally, which stimulate the involuntary muscles, permanent results, though not so speedily realized, can be obtained only by carefully developing the exterior muscles.

Sympathetic Relation Between Muscular Groups.—I am often asked by medical men whether the involuntary muscles, such as the heart and the muscles of digestion, are developed simultaneously with the voluntary muscles. My answer is, experience has shown me that a sympathetic development invariably takes place. It may be that the quickened circulation, the increased tissue change, the healthier physical elements created, act in this favorable manner upon the involuntary muscles, or it may be that the nervous relation between the two is the cause.

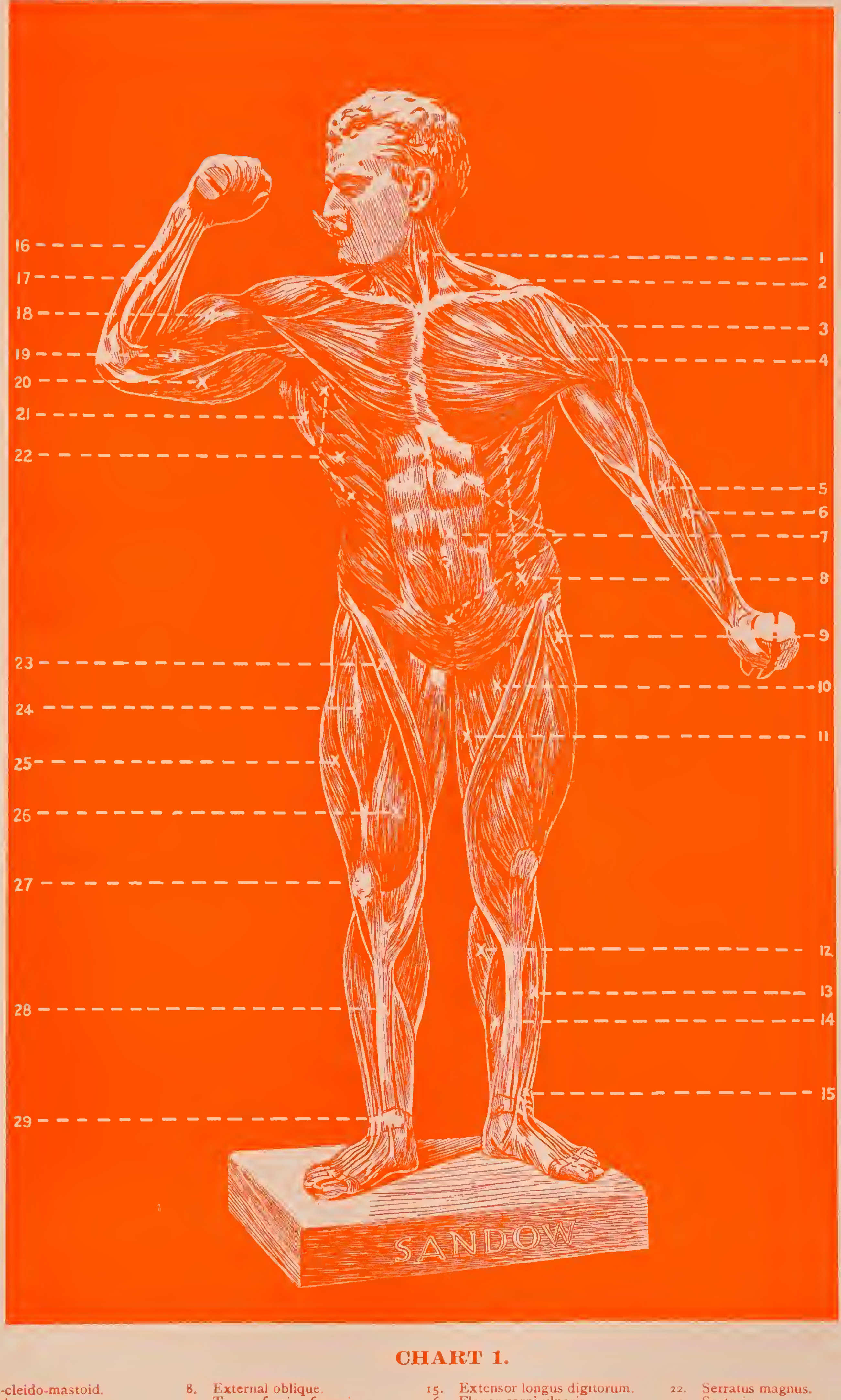


CHART 1.

1. **Sterno-cleido-mastoid.**
2. **Trapezius.**
3. **Deltoid (or shoulder).**
4. **Pectoralis major.**
5. **Extensor carpi radialis.**
6. **Extensor communis digitorum.**
7. **Rectus abdominis.**
8. External oblique.
9. Tensor fasciae femoris.
10. Pectineus.
11. Adductor longus.
12. Gastrocnemius (or calf).
13. Tibialis anticus.
14. Flexor longus digitorum
15. Extensor longus digitorum.
16. Flexor carpi ulnaris
17. Flexor carpi radialis.
18. Biceps (or front arm).
19. Brachialis anticus.
20. Triceps (or back arm).
21. Latissimus dorsi.
22. Serratus magnus.
23. Sartorius.
24. Rectus femoris.
25. Vastus externus.
26. Vastus internus.
27. Patella (or knee pan).
28. Tibia (or shin bone).
29. Annular ligament.

Aim at All-round Development.—I am afraid that in many cases the attention of the pupil is given too often to certain well known muscles. Too many watch the growth of the biceps and triceps with an exclusive eye. I myself prefer to see more attention devoted to the trunk muscles. You may take it for granted that the first time you stand before your mirror and see the abdominal muscles show faintly under the generous fatty covering with which your idleness and luxurious diet have clothed them, you have made a distinct advance in your physical education. In all the great and noble sculpture of ancient Greece you will invariably find this abdominal marking, both in man and woman. So long as this marking is present the body is never gross. In the degenerate age of sculpture which followed upon this—the age of Apollinos—this marking suddenly vanished, to be revived temporarily by the greatest master of medieval art, Michael Angelo. This marking is due to the development of the rectus abdominis muscle, which will be explained a little later.

No. 1. Chart 1. Sterno-Cleido Mastoid.—These muscles are two in number, one on each side of the neck. They arise from the sternum (breast bone) and clavicle (collar bone), and are inserted or attached by a strong tendon into the mastoid process and by a thin tendon into the occipital bone (behind the lower jaw). They are the largest of a group which controls the movement of the head both sideways and forward, also acting in elevating the thorax in forced inspirations. The proper development of these muscles adds grace to the carriage of the head. The habit of forcing the neck into high, close collars—a habit more common among women than men—is very harmful to these muscles, destroying their strength and restricting the movements of the head. Adipose tissue consequently quickly forms, and what is called the double chin is produced, which, when once gained, is difficult to remove.

No. 2. Chart 1. Trapezius.—The appearance of this muscle in full development is not generally understood. You have all heard of sloping shoulders and square shoulders, and it would seem that an eternal misunderstanding has arisen with regard to these. It is, of course, true that in a figure absolutely without development the sloping shoulders are a sign of weakness, and square shoulders give the promise of future strength; but when the body is developed, square shoulders only show that the trapezius has not taken its proper place. If it has received its due attention it should come down from the back of the ear in one long slope to the point of the shoulder. It is only when the trapezius has not been properly exercised that square shoulders are possible. The upper part of this muscle raises the shoulder and is brought into play in lifting movements, more especially, of course, in heavyweight lifting, where it is used to fix the shoulder whilst the deltoid is bringing up the arm.

No. 3. Chart 1. Deltoid.—This is so called because in shape it resembles the Greek letter Delta, but its form is that of a triangle with inverted base. It is a very thick muscle, and its coarse fibrous bands contract separately beneath the skin, like distinct muscles. It surrounds the shoulder joint and arises from the front border of the clavicle (collar bone), from the acromion process (point of shoulder), and from the lower edge of the spine of the scapula (shoulder blade). From these originating points the fibres converge to the centre, covering the shoulder joint, and unite to form a thick tendon, which is inserted at the middle of the outer side of the humerus (bone of the upper arm). The anterior (front) fibres, assisted by the pectoralis major (No. 4, Chart 1), elevate the arm and carry it forward; the middle fibres raise the arm sideways, while the posterior (rear) fibres, assisted by the teres major and the latissimus dorsi (No. 5, Chart 2, and No. 21, Chart 1) carry it backward. Although this muscle is very thick it cannot act with great power unless carefully developed by judicious exercise. When it is not developed the bony part of the shoulder is distressingly prominent, for it is deprived of its only clothing. A curious feature with regard to the development of this muscle is, that the greater its development the more sloping the shoulders. In order to possess a sturdy physique it is necessary to fully develop this muscle.

No. 4. Chart 1. Pectoralis Major.—This is a thick triangular muscle covering the front of the chest. It arises from the clavicle (collar bone) and from the centre of the sternum (breast bone), and as low down as the sixth or seventh rib. In fact, it may be said to arise from the cartilages of all the true ribs, sometimes omitting the first and seventh. The fibres all converge toward the place of insertion, terminating in a wide, flat tendon which is inserted into the outer and upper part of the humerus (bone of the upper arm).

This great chest muscle, when acting alone, draws the arm toward and across the front of the body and rotates the arm inwards. If the arm has been elevated by the deltoid the pectoralis major will, in conjunction with the latissimus dorsi

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This great chest muscle, when acting alone, draws the arm toward and across the front of the body and rotates the arm inwards. If the arm has been elevated by the deltoid the pectoralis major will, in conjunction with the latissimus dorsi and the teres major, draw the arm downward to the side of the chest. This muscle is large and strong, and when properly developed produces a full round chest and renders the lungs much less liable to affection. In woman this muscle is sadly neglected, consequently the bust becomes flabby and loose and is deprived of its natural beauty. High corsets are resorted to in order to support the bust where a well-developed pectoralis would perform this duty more gracefully and without the danger to health that lies in the artificial support. If this muscle is properly developed it elevates the ribs and consequently expands the thorax, and when this is done a protruding abdomen is impossible. A fully developed pectoralis must necessarily give a "straight front" below the chest. (See Cut 1.) One cannot have the one without the other unless artificial means are resorted to.

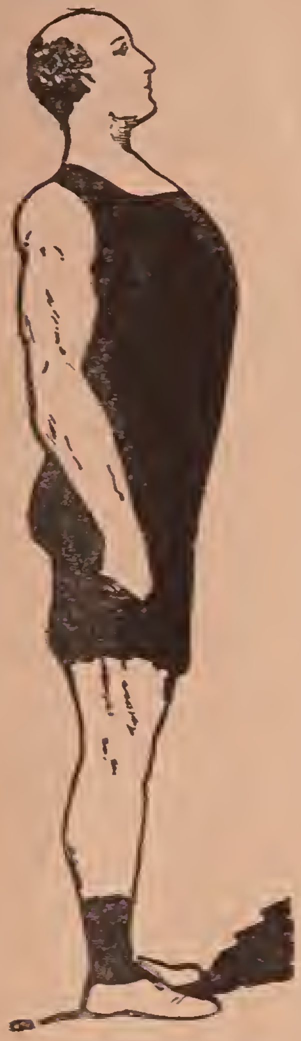


Fig. 1

No. 7. Chart 1. Rectus Abdominis.—This muscle forms a long, broad, fleshy band on both sides of the abdomen, covering the whole front of the abdominal region. It arises from the pubis (the front of the bony basin that supports the internal organs). The fibres extend upward and are inserted into the fifth, sixth and seventh ribs. During exercise the operations of this muscle are many—such as raising the head and shoulders when lying on the back and drawing the knees close to the chest by raising the pelvis (the bony structure to which the lower limbs are joined). They also assist the bowels in performing their natural functions and aid in expelling the urine from the bladder, as also the contents of the stomach in vomiting. Thus the importance of maintaining this muscle in a healthy condition is obvious. The most important function of this powerful muscle is that of keeping the internal organs in their place. To do this successfully it must always be strong and healthy, otherwise the weight of these organs would in time cause the muscular wall to bulge out and form a protruding abdomen. (See Cut 2.) Neglect to keep this muscular band firm and taut will directly or indirectly lead to a large percentage of ailments, such as constipation, liver and kidney troubles and rupture.

In the ordinary individual this muscle is thin, sometimes even transparent, with no power of tension; and indeed in most cases it is usually lax and pendulous, offering no support whatever to the abdominal wall.

The rectus abdominis receives its proper development only through systematic exercise, for one might engage in many athletic sports without altering its condition to any appreciable degree. As a rule there are three tendinous markings across this muscle above the navel, dividing it into four distinct bellies, which have been well compared to the old-fashioned scrubbing board. In a further stage of development there is a suggestion of another tendinous line, half-way between the navel and the pubis. This, however, is not shown in the ordinary anatomical text-book.

The rectus muscle, although so commonly neglected, is capable of taking on enormous strength and development, thus not only adding to the bodily power, but also to the beauty of the torso. Its development, together with that of the other abdominal muscles, is an absolute preventive of hernia. Preventive, I say, not a cure. The only cure for hernia lies in operation. The only other muscle which shows itself externally is the external oblique (No. 8, Chart 1), which may be seen on either side of the rectus muscles running upward and outward to interdigitate with the serratus magnus. This and the muscles underlying it I call the "Greek muscle," because it is nowhere seen in such perfection as in the statues of the ancient Greeks.

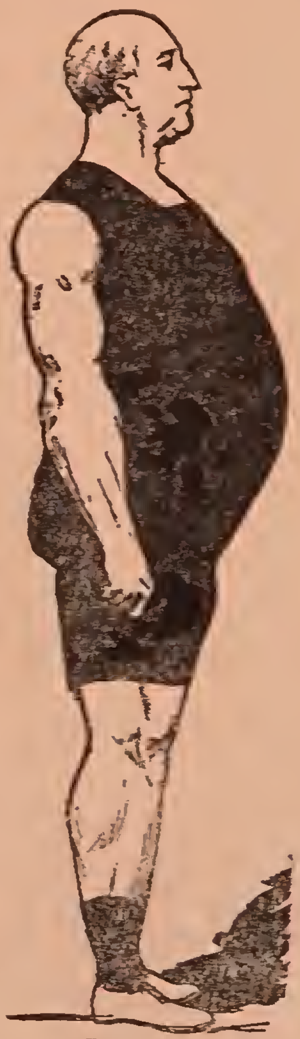


Fig. 2.

Notwithstanding the importance of the rectus abdominis, it is again and again weakened by men who overload their stomachs with food and drink,

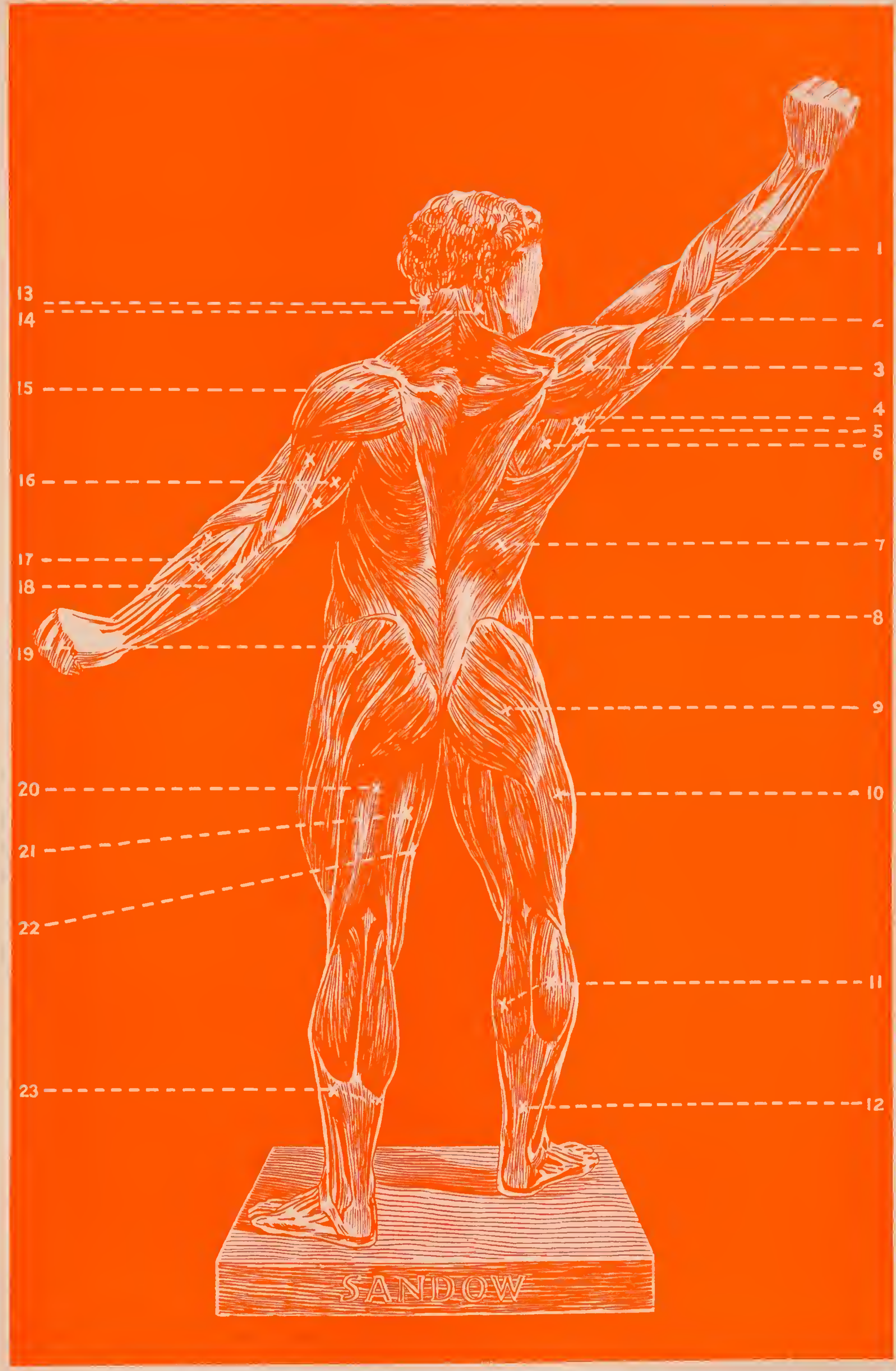


CHART 2.

1. Supinator longus.
2. Triceps.
3. Deltoid.
4. Teres minor.
5. Teres major.
6. Infra-spinatus.
7. Latissimus dorsi.
8. Posterior portion of external oblique
9. Gluteus maximus.
10. Vastus externus.
11. Gastrocnemius.
12. Tendon achillis
13. Sterno-mastoid.
14. Splenius capitis.
15. Trapezius.
16. Triceps.
17. Extensor carpi radialis longior.
    Extensor carpi radialis brevior.
    Extensor communis digitorum.
18. Extensor carpi ulnaris.
19. Gluteus medius.
20. Biceps.
21. Semi-tendinosus.
22. Semi-membranosus.
23. Soleus.

in doing which they add to the weight which must be supported; and women will suffer untold agonies by substituting for this natural means of support, artificial braces. Men have even prided themselves upon this undue prominence, and would have others think it a sign of opulence, while it is really an indication of ignorance, for which they will in time suffer. In exercising this muscle there is great danger of over-straining, therefore too much care cannot be taken. Few people pay attention to this muscle while walking, and although it is just as easy to cultivate the habit of holding the abdomen in so as to prevent it bulging forward, it is seldom done. (See Cut 2.) By holding the abdominal wall firmly the chest wall is necessarily raised, which gives an upright poise to the head, and there results what we call a correct carriage.

People lay great stress upon the importance of abdominal breathing, to the neglect of the upper lung development. While it is correct to begin the inflation of the lungs at their base (the abdominal portion), yet it is the apex that needs the greatest attention, in order to guard against consumption and other lung troubles. Moreover, if a full rounded chest and a flat abdomen are to be obtained (sure indications of good health), the correct development of the great chest and abdominal muscles and of the upper part of the lungs is absolutely necessary.

A simple experiment will suffice to prove the direct relation between the abdomen and the chest. Raise the chest, and observe that the abdomen recedes. You cannot prevent this if you would. As a second experiment, draw in the stomach, press back the hips and watch the chest rise. (See Cut 1, page 1640.) This correct attitude is just as easy to cultivate as the usual wrong one. It is a fact that it is absolutely impossible to have a weak and protruding abdomen and a fully developed chest, or *vice versa*.

No. 8. Chart 1. The External Oblique.—This is a large sheet of membrane, half fleshy and half fibrous (aponeurosis), covering the lateral (side) and anterior (front) surfaces of the abdomen. The fleshy portion is attached to the external part of the eight last ribs, and is interlaced with the digitations of the latissimus dorsi and the serratus magnus (Nos. 21 and 22, Chart 1). From these attachments the rear part of the fleshy fibres extends downward to be inserted into the crest of the ilium (hip bone), and the front portion terminates in a fibrous membrane and is inserted in the os pubis (the lower part of the bony basin that supports the internal organs). The chief function of this muscle is to bend the body sideways, and also to assist in bending it forward by uniting with the rectus abdominis. This forms a powerful muscular waist belt. This external oblique is especially active in movements which squeeze the liver (and no liver can be called healthy unless thoroughly squeezed every day). Children at school, if allowed to sit or stand incorrectly, will soon acquire a one-sided development of this muscle, thus causing the irregularity of hips which is becoming so common in young school girls; or it may result in a depression of one side of the chest, which, if not corrected by suitable exercise, will retard the proper development of the lung. Owing to its formation, the obliquus, as it is commonly called, is more difficult to harden by exercise than the rectus abdominis. Physical culture enthusiasts often fail to understand this. If the obliquus and the rectus abdominis are well defined and brought into good condition by exercise, then the possessor of these can lay claim to a true bill of health. One reason why so much stress is laid upon the development of this muscle is because to its weakness may be traced the frequent cases of rupture (chiefly inguinal). The lifting of heavy objects, a misstep on the street, or even a violent fit of coughing, are among the direct causes of rupture. So it will readily be seen that the strengthening of this muscular band is a necessary means of protection against such accidents.

The anatomical reason for the stress laid here upon this danger is due to the fact that through the fibrous membrane of the obliquus, referred to above, the spermatic cord in man, and a large round ligament in woman, passes; and since the spermatic cord is the larger of the two, and necessarily has a larger aperture for its passage, inguinal hernia, or rupture, is consequently more frequent in man than in woman. This danger, however, may be lessened by the constant practice of a few simple abdominal movements.

No. 9. Chart 1. The Tensor Fasciæ Femoris.—This muscle arises from the front part of the hip bone and is inserted into the outer side of the thigh. Its principal uses are: To adduct and rotate the thigh inward, to assist the gluteus maximus in supporting the knee in an extended position, and to offer great support to the pelvis and the head of the thigh bone (femur).

No. 10. Chart 1. The Pectineus.—This is a flat quadrangular muscle which arises from the rim of the pelvis and is inserted into the inner part of the thigh bone. This muscle assists the adductors in adducting the thigh, especially in horseback riding, in rotating the thigh outward, and when walking it assists in drawing the leg forward.

No. 11. Chart 1. Adductor Longus.—This is a flat triangular muscle and arises from the os pelvis (front of the pelvis), and is inserted into the inner part of the thigh. This is one of the three great adductors of the thigh. The adductor brevis and adductor magnus, which are not shown on the chart, are situated behind the pectineus and adductor longus, and therefore are not visible unless these muscles are divided at their origin and turned downward. The adductor longus, in conjunction with the pectineus (No. 10) and the other two adductors, are much used in walking, horseback riding and in swimming. The flanks of the horse are grasped by the knees with the aid of this muscle. These muscles also draw one leg across the other. The adductor longus, if not properly developed, is easily strained in skating and horseback riding. Horsemen often rupture the tendon of this because the fibres are not strong enough to withstand the strain of gripping the flanks of the horse. The tendons sometimes become ossified, making the thighs "bowed."

Nos. 13 and 15. Chart 1. Tibialis Anticus (13) and Extensor Longus Digitorum (15).—The tibialis is situated on the outer side of the tibia, the larger bone of the lower leg (the shin bone). It arises from the upper part of the tibia and passes downward, terminating in a tendon which is inserted in the under side of the base of the great toe.

The extensor longus digitorum is the outermost of the muscles of the front part of the lower leg. It arises from the tibia and the three upper parts of the fibula (the small bone of the lower leg). The tendon of this muscle is divided into four strips which pass over the front part of the foot and are inserted into the ends of the outer four toes. These muscles draw the toes toward the front part of the leg, and also serve to keep the legs perpendicular. The practice of walking on the heels will strengthen these muscles very much; and walking up hill or mountain climbing will quickly test their strength.

No. 14. Chart 1. Flexor Longus Digitorum.—This muscle arises from the near upper part of the tibia, the fibres terminating in a tendon which passes under the sole of the foot, where it divides into four tendons which are inserted into the outer four toes, which is the reverse of Nos. 13 and 15, described above. This muscle is particularly used in walking, and also in rising on tiptoes. In-toed walking is caused by the excessive strength of the tendons of this muscle, but this deformity can be remedied by certain exercises.

Nos. 16, 17. Chart 1. Flexors of the Forearm.—These close the hands and draw the palm toward the forearm. Their strength is indicated by the power of the grip. The healthier the person the stronger will be the clasp of the hand.

No. 18. Chart 1. Biceps.—Here we have a double-headed muscle; the shorter head, arising in a thick tendon from the coracoid process (a part of the shoulder girdle), is joined by the coracobrachialis muscle (No. 19). The long head arises from the upper edge of the glenoid cavity (shoulder joint). Both heads extend downward and unite, terminating in a flattened tendon, which is inserted in the radius (small bone of the forearm). This muscle forms a large round bunch when the hand is brought to the shoulder. Its work is the opposite of that of the triceps (No. 20); for, while the latter straightens the arm, the biceps contracts it. Any movement bringing the hand to the shoulder is done by the biceps. It is this bunch of fibres which athletes take so much pride in developing, and in their zeal often bring about a condition called "muscle bound;" that is to say, the biceps are developed at the expense of the triceps, causing the arm to have a bent appearance when hanging at the side.

No. 19. Chart 1. Brachialis Anticus.—This muscle comes to the level of the deltoid impression and is attached to the humerus. The fleshy fibres extend nearly to the elbow and are continued by a flat tendon and inserted into the base of the coronoid process of the ulna (the head of the largest bone of the forearm, which forms a part of the elbow). This is simply a flexor of the forearm, and bunches up in a round ball on each side of the lower part of the biceps when the arm is bent, and forms a protector to the elbow joint.

No. 20. Chart 1. Triceps.—This muscle is situated on the back of the arm, and is divided at the top into three heads, hence its name. The three heads arise from the socket of the shoulder and rear portion of the humerus. They unite just above the elbow and are inserted partially at the elbow joint, and are partially blended with the deep fascia of the forearm. The middle head, if properly developed, will prevent the dislocation of the shoulder downward and backward. This muscle is directly antagonistic to the biceps; it is an important agent in straightening the arm and is difficult to fully develop. In fact, enthusiasts are more apt to neglect it by giving over-attention to the biceps. This one-sided development brings with it a sense of fatigue in the arm after exercise; for, not being equally trained and equally brought into action, the biceps and triceps do not rest together properly. An exercised muscle needs rest, but if its antagonist has been neglected, then the tired muscle cannot properly recuperate, and hence its unnecessary fatigue.*

No. 22. Chart 1. The Serratus Magnus.—This muscle has nine points of origin and arises from the first eight ribs, the second rib giving origin to two points. The fibres pass rearward, clinging closely to the chest wall, and are inserted into different parts of the vertebral border of the scapula. The four lower points entwine with the external oblique. (No. 8.) The serratus is a very powerful muscle, and is especially used in pulling the scapula forward, also in the action of pushing; when the arm has been raised to right angle by the deltoid (No. 3), the serratus assists the trapezius (No. 2) in raising the arm to a vertical position, and when the shoulders are fixed this muscle helps in raising the ribs when a deep breath is taken. The weakness of this muscle is mainly the cause of a certain winged appearance at the back, which is more prevalent among women than men. This results from the fact that women cannot with ease raise the arms above the head while wearing a modern cut garment, but is supplemented by the non-fashionableness of the movement.

No. 23. Chart 1. The Sartorius.—This is the longest of all the muscles. It arises from the front edge of the hip bone, and passes, ribbon-like, obliquely across the front of the thigh, and terminates at the knee in a tendon which expands and curves forward to be inserted into the inner part of the tibia. The sartorius is commonly called the tailor's muscle (sartor, a tailor), as it comes greatly into use with tailors when sitting at their work on the bench. This muscle assists in drawing the knee upward, at the same time drawing the lower part of the leg upward and inward; and when the knee is bent it will assist in rotating it inward, as is required in doing what is called the "corkscrew" in dancing.

No. 24. Chart 1. Rectus Femoris.—This muscle greatly assists in supporting the pelvis and trunk on the femur (thigh bone). It arises by two tendons, one from the front part of the ilium (hip bone), the other from the edge of the acetabulum, the cup-like cavity of the pelvic girdle; the two unite and descend, terminating in a flattened tendon which is inserted into the patella. The football and baseball player calls into action this muscle again and again. When not properly developed, if any strain is placed upon the rectus femoris, a sharp pain is felt, the rectus becomes rigid, and often swells considerably.

No. 25. Chart 1. Vastus Externus.—This is the muscle which forms the largest part of the extensor muscles of the thigh. This arises from many points of the upper part of the femur (thigh bone) and also from the gluteus maximus (see Chart 2). The fibres form a large fleshy mass, and terminate in a flat tendon which is inserted into the outer edge of the patella (knee cap). It is this muscle that stands out most prominently when the thigh muscles are fully developed. It is very important that this muscle should be fully developed, in order to insure buoyancy and elasticity of step, which are associated with a graceful carriage.

No. 26. Chart 1. Vastus Internus.—This is another of the great extensors of the thigh, which arises from various points of the thigh bone and is inserted into the inner part of the patella. This muscle also plays an important part in the carriage of the body. When the foreleg has been fully extended on the thigh, the vastus internus will draw the knee cap farther back and upward, thus making the leg rigid. By placing the hand over the knee when the leg is straight, and pressing the knee cap back, the action of this muscle can be felt.

No. 29. Chart 1. Annular Ligament.—This serves to bind down the tendons of the muscles as they descend from the tibia and fibula into the foot.

No. 1. Chart 2. Supinator Longus.—This is the most superficial muscle on the radial side of the forearm. It arises from the humerus and terminates in a flat tendon which is inserted into the outer side of the radius. It is principally this muscle that turns the palm of the hand upward (supernate).

No. 4. Chart 2. Teres Minor.—This muscle arises from the scapula and is inserted into the humerus, the tendon covering the posterior part of the ligament of the shoulder joint. It assists in rotating the head of the humerus outward and in retaining the arm in position when raised, also in carrying it backward. Combined with the infra-spinatus (No. 6), the teres minor, if properly developed, prevents the dislocation of the shoulder backward.

No. 5. Chart 2. Teres Major.—This is a thick, flattened muscle which arises from the scapula and is inserted into the bicipital ridge of the humerus. The teres major, assisted by the latissimus dorsi (No. 7), draws the arm, when raised, downward and backward and rotates it inward.

No. 6. Chart 2. Infra-Spinatus.—A thick, triangular muscle. It arises from the scapula and is inserted into the great tuberosity of the humerus. For its actions, see No. 4.

No. 7. Chart 2. Latissimus Dorsi.—This is a broad, flat muscle covering a greater part of the back. It arises from the six inferior dorsal vertebræ and from the posterior layer of the lumbar fascia, by which it is attached to the spines of the lumbar vertebræ and to the supra-spinous ligament. It also arises from the external lip of the crest of the ilium, behind the origin of the external oblique, and by fleshy digitations from the three or four lower ribs. From this extensive origin the upper fibres pass horizontally, the middle ones obliquely upward, while the lower ones pass vertically upward. These all converge and form a thick fasciculus, which crosses the inferior angle of the scapula, curving around the lower border of the teres major. It then terminates in a short tendon which passes in front of the teres major and is inserted into the bicipital groove of the humerus.

The actions of this muscle are to draw the arm backward, to adduct and rotate it behind the back. In giving a downward blow it is this muscle that is principally used. In the days of double-handed sword fighting this muscle had to be well developed to be of any use to the swordsman. Gladstone had a remarkable development of this muscle, obtained from felling trees. The latissimus greatly assists in forcible inspirations; also, combined with the abdominal and pectoral muscles, in drawing the trunk forward when both arms are fixed at the sides, as in walking on crutches.

No. 9. Chart 2. Gluteus Maximus.—This muscle is in size one of the most characteristic points in the structure of the human body, and is the principal agent in maintaining the body in the erect position. It arises from the superior curved line of the ilium, from the crest of the same bone and from the posterior surface of the lower part of the sacrum; also from the coccyx. The fibres are directed obliquely downward and outward, and inserted into the outer side of the thigh. Its most powerful action is to bring the body to the erect position after bending from the hip joint. The lower part of this muscle also acts as an adductor and an external rotator of the leg. It is obvious that this muscle should be thoroughly developed if a correct carriage is to be maintained.

Undue prominence does not indicate strength. A woman predisposed to being fleshy will find this part become in time very ungraceful by the accumulation of adipose tissue, caused by the wearing of corsets, the fat being dispersed from the abdomen and back muscle downward, while a few simple abdominal movements practiced daily would entirely obviate this, besides maintaining the whole of the abdominal and gluteal region in a perfectly healthy condition. The development of this muscle, curiously enough, is the chief distinction between man and the monkey. In monkeys and apes the muscle is small and ill-developed, because it is not required. It is by means of the gluteal muscles that man maintains the standing posture, and consequently in man they are of exceptional size. Bending movements bring these muscles into play.

No. 11. Chart 2. Gastrocnemius.—This muscle forms the greater part of the calf. It arises in two parts, which are connected to the condyles of the femur by two strong flat tendons descending. The fibres unite with the tendon of the soleus (No. 22) and form with it the tendon Achilles (No. 12).

This muscle possesses considerable power and is constantly called into action; in fact, it may be said to do more work than any other single muscle, hence its large size. It is the principal muscle used in walking, standing, dancing and leaping, and, owing to its being continually exercised, it is always in a fully developed condition; consequently, systematic exercise has very little effect, which is often a disappointment to the enthusiastic. One never knows when the increase in the size of the calf muscles will cease. It sometimes happens, particularly if exercise is not indulged in too fiercely, that they go on increasing without limit. Again, they may suddenly make a stand.

No. 14. Chart 2. Splenius Capitis.—This muscle is one of two (the other being named the splenius colli) which are situated at the back of the neck and are anatomically described as the splenius. At its origin it is a single muscle, but it soon divides, forming the splenius capitis and splenius colli. They arise from the cervical and dorsal vertebræ. The splenius capitis is inserted into the occipital bone. This muscle assists its fellow in drawing the head backward and sideways; they also assist in supporting the head in the erect position.

No. 17. Chart 2. Extensor Carpi Radialis Longior. Extensor Carpi Radialis Brevior. Extensor Communis Digitorum.—These muscles act directly antagonistic to the pronator and flexor muscles of the forearm. They arise from the humerus, the extensor longior being attached to the index finger on its radial side. The extensor brevior is attached to the middle finger on its radial side, while the extensor digitorum divides into three distinct fleshy masses just below the middle of the forearm, from which tendons proceed. These pass through a separate compartment of the annular ligament; the tendons then diverge, the centre one dividing into two, all passing across the back of the hand, and are inserted into the second and third phalanges of the fingers in the following manner: The outermost goes to the index finger, the second tendon goes to the middle finger, the third tendon gives off the slip to the second and receives, in turn, a part of the fourth tendon. The fourth or innermost tendon divides into two parts; one goes to join the third tendon, the other goes to the little finger.

No. 18. Chart 2. Extensor Carpi Ulnaris.—This is the most prominent muscle on the ulna side of the forearm. It arises from the humerus, also the posterior border of the ulna. This muscle terminates in a tendon and is inserted into the metacarpal bone of the little finger.

The extensor brevior assists the extensor longior in extending the wrist, also in adducting the hand. The extensor digitorum extends the phalanges of the fingers, wrists and elbow. The extensor ulnaris assists in extending the hand; also, when acting alone, inclines it toward the ulna side, and by its continued action extends the elbow.

There are several other muscles, not shown here, that assist in extending the hand and fingers, such as the extensor minimi digiti, the anconeus, the extensor ossis metacarpi pollicis, the extensor brevis pollicis, the extensor longus pollicis, the extensor indicis. To a pianist it is of the utmost importance that these muscles are correctly developed. Many good pianists break down owing to the neglect to do this at the early stages of tuition. In fact, there is a stupid prejudice against exercising the hand other than by practice on the piano or clavier, because it is said that other kinds of exercise would stiffen the fingers. This might perhaps be true if the exercises were injudiciously given.

No. 19. Chart 2. The Gluteus Medius.—This is a broad, thick muscle, situated on the outer surface of the pelvis. It arises from the ilium; the fibres converge into a flattened tendon, which is inserted into the great trochanter (part of the femur). This muscle assists in adducting the thigh when the leg is extended, and is principally called into action when balancing on one leg.

No. 20. Chart 2. The Biceps of Thigh.—This muscle arises by two heads, one from the tuberosity of the ischium (part of the pelvis), the other from the lip of the linea aspera (part of the femur), and is inserted by a tendon into the outer side of the head of the fibula and partially into the tibia.

No. 21. Chart 2. The Semi-Tendinosus.—This muscle possesses a remarkably long tendon. It arises from the ischium in common with the biceps (No. 20); it passes downward and inward, terminating a little below the middle of the thigh in a long, round tendon which is inserted into the inner surface of the tibia.

No. 22. Chart 2. The Semi-Membranosus.—This muscle arises by a thick tendon from another part of the ischium, and is inserted into the tibia.

Nos. 20, 21 and 22 form the hamstring muscles. These all three unite in flexing the lower leg on the thigh. They are greatly used in supporting the pelvis upon the head of the femur, also in performing great feats of strength when the body is thrown backward in the form of an arch. The inability to touch the floor with the fingers while keeping the legs straight is partially owing to the want of elasticity of these muscles; and again, when this particular exercise is performed correctly for the first time, extreme lameness may be experienced in these muscles. It is astonishing how much elasticity can be cultivated in the hamstrings by the practice of bending forward from the hip joint. At first a beginner may only be able to touch the toes, but by persistent practice a distance of twenty to thirty inches from the toes may be attained. This exercise may be said to be one of the best for stimulating the growth of the body and of strengthening those past the growing age, thus adding perhaps an inch to the height.

No. 23. Chart 2. The Soleus.—This is a broad, flat muscle situated beneath the gastrocnemius. It receives its name from its resemblance to a fish (sole). It arises from the head and upper third portion of the fibula. The fibres, as they descend, gradually become thicker and narrower, and join with the gastrocnemius and form with it the tendon Achilles. This muscle greatly assists the actions of the gastrocnemius.

The Hand.

The Power of the Hand.—I now propose to add a short description of the hand, showing its structure and possibility of development. Man is distinguished from other animals by being a tool-using animal. Every other creature has its means of attack and defense supplied by nature; man alone is defenseless. But to compensate for this weakness he has a hand so marvelously formed that by its use he can make for himself what nature denied. Its anatomical freedom, its delicacy and freedom of movement, adapt it for the heaviest or most delicate work, so that by reason of the hand man can fashion anything from an ironclad to a miniature chronometer. The hand can wield alike the sword, the hammer and the pen, and it is by this tool-using power that man is the monarch of creation and that civilization is made possible. It is the organ of the mind, both for creation and expression. So the hand has come to be with us a symbol of dignity. We speak of an honest hand, we shake hands in greeting, and give our hands on a bargain as an irrevocable pledge.

The Thumb Peculiar to Man.— Perhaps the most absolute distinction between the human hand and the hand of other animals is the strength, length and mobility of the thumb. Man is the only animal that has a ball to the thumb, and that can with strength and precision oppose the thumb to the other fingers. This power is partially possessed by some of the monkey tribe, but in other animals it is wholly absent. If you look at Fig. 5 you will see the mass of muscle and tendon constituting the ball of the thumb. Four powerful forearm muscles are employed in the extension and flexion of the thumb, and five smaller muscles oppose, abduct, adduct and give precision and delicacy to its movements.

Further Differentiations from the Lower Animals.—Again, the possession of two bones in the forearm, *radius* and *ulna,* makes possible a rotary motion of the hand. In hoofed animals these bones are united so that rotation is impossible. Man has a special fixed formation of the shoulder joint to give a firm base for the limb to move upon; consequently when he falls on his hand the elbow joint is locked, and either a dislocation or fracture is apt to take place at the shoulder. In four-footed animals the shoulder joint is loose and the fore-limbs attached to the trunk by muscles alone. In these animals the whole weight in alighting is turned upon the *serratus magnus* (see Chart 1, No. 22), which is consequently of exceptional size and power. It will be seen from these few illustrations that the anatomical arrangement of the forelimb in man is peculiar to him, being adapted to the new use of that limb as a tool-using member and not as a means of progression and attack.

Another general difference between the formation of the forelimb in man and in other animals is the length of the clavicle, which keeps the shoulders out and fixed so that a free lateral movement is possible. In claw-bearing animals—the lion and tiger, for example—when there is little lateral movement of the forelimb, the clavicle is quite rudimentary and is usually imbedded in the muscles, being just a vestige. The hoofed animals have no clavicle at all.

Theories for Ambidexterity.—One of the most interesting questions in regard to the hand is that of right and left-handedness. Some have labored to discern a similar preference for the use of the right side in other animals, but without result. Whatever may be the cause, it certainly originates with man, and is accompanied by certain anatomical peculiarities which we shall shortly notice. Our reason for this preference is that the heart, being accessible from the left side, makes that side the shield-bearing side, leaving the right arm for the more varied duties of attack. Supporting this, of course, is the fact that all primeval life must have been warlike, necessitating some such differentiations, which, repeated from generation to generation, brought with them of necessity their own physical and anatomical peculiarities. We find the Greeks used the words *ἐπὶ δόρυ* (spear arm) for the right arm and *ἐπ' ἀσπιδα* (shield arm) for the left arm. Another reason assigned is the motor specialization on the left side of the brain, which, by the discusation or crossing of the nerve fibres, controls the right side of the body, though it is probable that this is a consequence rather than a cause. That there is still a motor area in the right side of the brain is shown by the fact that electric stimulation of the nerve cells on that side relating to certain nerves is followed by the required movement, though not so strongly as in the specialized motor areas on the left side of the brain. In diseases of the left hemisphere of the brain the right hemisphere may to a great extent acquire this motor specialization.

Other Theories for Dexterity.—A third and very interesting reason for dexterity, brought forward by Dr. Buchanan, of Glasgow, is the fact that the right side of the body is heavier than the left, so that the weight is thrown on either foot according as the center of gravity is situated above or below the transverse axis of the body. Hence one limb would be the balancing foot and the other the one adapted to more delicate and stronger movements. Whatever be the cause, the fact remains productive of endless speculation. Everything we do is modified by our right-handedness. A left-handed man is awkwardly placed with his fellows. From the smallest matters, such as holding a knife and fork or opening a penknife, to the greatest, such as taking his place among an organized body of men, he finds everything awry, and has slowly to learn what to others is a natural convention. Another result of right-handedness is the inclination, in passing people, to keep them on the left or shield side—a custom universal in all countries. But we cannot here examine this curious question scientifically; let it be enough to notice two points which have interest to students of physical culture.

The Left Hand Should be Developed. — Many authorities regard the left side as being not only less apt than the right, but actually more subject to disease. Dr. Brown-Séquard, in "Have We Two Brains?" touches on the subject of the nervous system, and makes this striking statement, which I would recommend to the careful consideration of my readers: "Perhaps fathers and mothers would be more ready to develop the natural powers of the left hand of a child if they believed, as I do, that the conditions of the brain and spinal cord would improve if all their sensory and motor elements were fully exercised."

Ambidexterity, I believe, should be taught every one, not only for the great advantages it affords in life, but also for the increased health of nervous and other organs resulting from the perfect balance or development in the two sides of the body. In considering merely in detail the muscular structure of the forearm and the hand, I shall touch upon anatomical points only lightly, and avoid all technical description, which may easily be obtained in any standard work on anatomy.

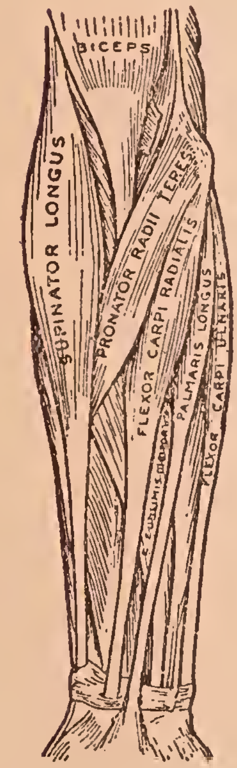


Fig. 1.

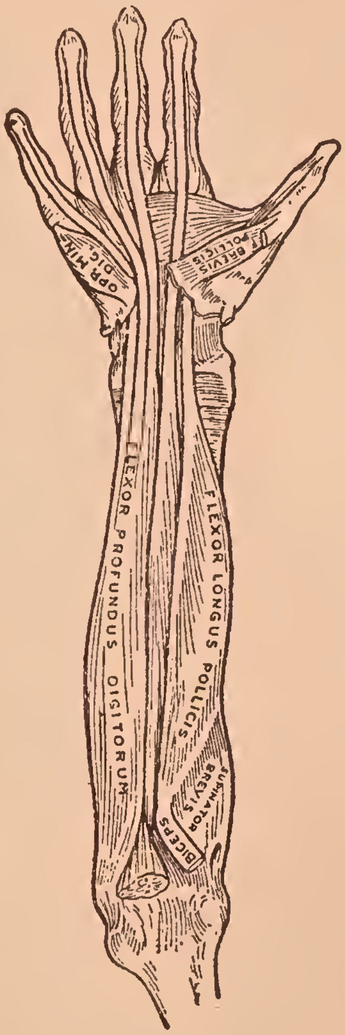


Fig. 2.

Peculiar Construction of the Hand.—A muscle is a contractile tissue attached at its ends to bones, and when it contracts brings these bones together. At its point of attachment the bone is rough, to give ground for the tendinous fibres to rise from; and the more powerful the muscles, the rougher and stronger the bones, so that by glancing at a skeleton one can tell the state of muscular development that existed, both generally and in detail.

Ulna and Radius.—It is to be observed, first, that while the *ulna* (or bone of forearm of the little finger side) is securely locked in the elbow joint, the *radius* (or bone of the thumb side of the forearm) is quite free from the elbow joint. But yet, while the hand is intimately attached to the radius, it has but little connection with the ulna, thus making radiation of the hand possible. The ligaments connect the two bones, permitting the radius to move around the ulna and carry the hand with it.

Pronation and Supination.—When the palm of the hand is turned downward this movement is termed *pronation;* when the palm is brought upward it is called *supination.* For pronating the hand there are two muscles—the *pronator radii teres,* seen in Fig. 1, and the *pronator quadratus,* seen in Fig. 2—beneath the tendons of the deep flexors. For supinating we have two muscles—the *supinator longus,* seen in Fig. 3, and the *supinator brevis,* a deep muscle, seen in Fig. 4. Besides supinating the hand, the *supinator longus* assists with the biceps to flex the arm when flexion has once commenced. The other superficial muscles of the flexor side of the forearm, seen in Fig. 1, are flexors of the wrist, which bend the hand on the forearm. The middle one, *palmaris longus,* extends farther and is inserted into the very strong and dense *fascia* on the palm of the hand with the *palmar fascia.*

The Flexors.—Just beneath this layer, in Fig. 1, is the second layer, the *flexor digitorum sublimis* which bends the fingers up to the second joint. Beneath this, again, is the third layer, seen in Fig. 2 — the *flexor profundus digitorum,* which bends the last joint, or tip of the fingers, and the *fllexor longus pollicis,* the long flexor of the thumb, which bends the last joint of the thumb. It will be observed how powerful this combination of flexors is, especially when supported by the short flexors, which lie altogether in the hand and do not spring from the forearm. In very young children—a week or two old—these flexors are so powerful that the child will hang from a rod with its hands for many minutes at a stretch, supporting its whole weight thereby. Such a thing is impossible even with the most powerful man, and zoölogists use this fact to plead for the descent of man from the ape.

The Extensors.—In Fig. 3 are seen the extensors of the wrist and forearm, there being three extensors of the wrist, a common extensor for the four fingers and a special extensor each for the first finger and the fourth finger in addition. It is by reason of this latter fact that we can so readily extend the first and fourth fingers and use them as indicating fingers when we wish to point to an object. In the deeper layer of extensor muscles on the back of the arm, underlying the foregoing—seen in Fig. 4—are the three extensors for the thumb, one for each joint, the metacarpal bone, the first phalanx and the second phalanx. I have pointed out how thoroughly the thumb in man was supplied with muscles, and that it was due to the mobility and strength obtained by this specialization that the hand of man was distinct from that of any other animal, and that civilization was made possible.

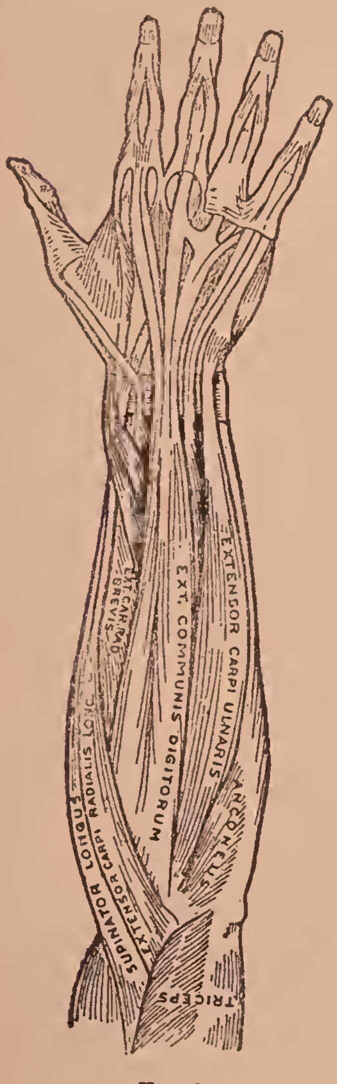


FIG. 3.

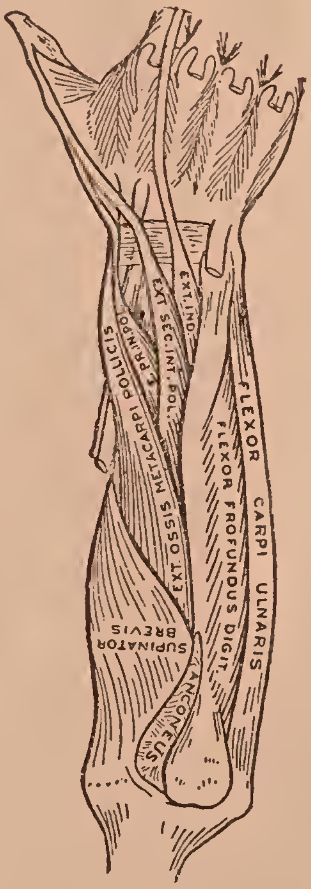


FIG. 4.

The Pollicis.—In coming to the hand proper we deal mostly with Fig. 5. Here we see the thumb has a short flexor, the *flexor brevis pollicis,* in which two tendons sesamoid bones form, giving the hardness and prominence to the palmar aspect of the joint where the thumb joins the hand. These sesamoid bones give leverage to the action of the muscle so that it has more power. Then we have a muscle for abducting the thumb, the *abductor pollicis;* one for opposing the thumb to meet the finger tips, *opponeus pollicis,* and one to draw the thumb toward the fingers—the abductor pollicis mentioned above.

The Interossei.—The little finger has precisely the same set of muscles, with the exception of the abductor muscle, its place being taken by the *palmar interossei.* These interossei muscles occupy the space between the metacarpal bones — the one set on the back of the hand being called the *dorsal interossei,* seen in Fig. 4, and the other set on the palm of the hand, the *palmar interossei,* which are not shown in any of the plates—the *palmar interossei* drawing the fingers together and the *dorsal interossei* separating them fanwise.

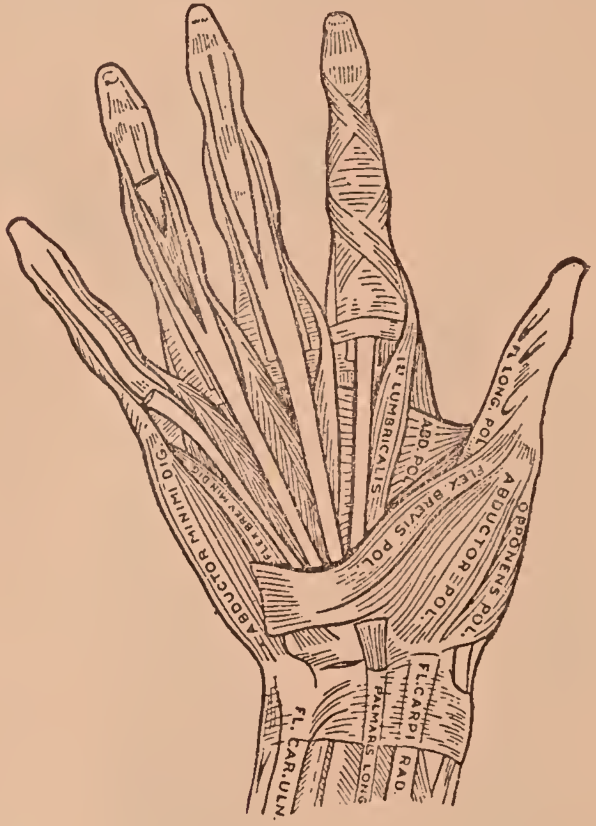


FIG. 5.

Palmar Brevis.—Another muscle, shown in Fig. 5, is the *palmaris brevis.* It is unnamed in the plate, but may be seen originating in the section of the palm and spreading outward on the ulnar side of the hand, to be inserted in the skin. It draws the skin on the outside of the hand into the palm. It is by means of this muscle that we form the "cup of Diogenes" when we are drinking water from the hollow palm. When Diogenes renounced superfluities, you remember, he still retained his cup to drink out of. But one day he saw a boy scooping up water in his hollow palm, and he cast away his cup as an unnecessary burden; hence it is called the cup of Diogenes. In making a fist this muscle causes compactness by gathering in the outer side of the palm; the wrinkles and depressions in the skin while doing so may easily be observed.

Lumbricales.—By far the most delicate arrangement in the anatomy of the hands is that effected by the *lumbricales* muscles, seen in Fig. 5. These are small slips of muscles passing over the tendons of the deep flexor of the fingers as they pass through the palm of the hand. From the tendons of the deep flexors they pass between the fingers to the back of the hand, and are inserted there into the tendons of the extensor of the fingers. You may ask, "Why is this communication?" It is because in many of the movements, when the last joint of the fingers is bent forward the first joint is moved backward or extended.

Take a pen in your fingers and you will see what I mean; point it out as far as you can and withdraw it several times. You will notice that while the last joint of the finger flexes the first joint extends. It is by means of these little slips of muscle—the lumbricales—that this movement is under such delicate control. In all flexion the muscles of extension are not quiescent, allowing the flexors to act alone. On the control they are in action, limiting and controlling the flexors, and it is by this means that we have delicacy and subtlety of movement. In this one instance there is actually a muscular connection between the flexors and the extensors in the part when the need for delicate and precise adjustment is most necessary. It must be remembered that, although we are accustomed to muscles acting singly, they really work in groups, and the movement of flexion is achieved not only by the coördination of many flexor muscles, but also by the controlling or regulating power of the extensor groups. How intricate this grouping is may be seen from the fact that the slight strain of some fibres of one muscle in the arm makes any movement of the arm painful. Yet in spite of the wonderful delicacy which all muscular movements of the hand show, one is astonished at the clumsiness and weakness with which any new and unaccustomed movement is performed. The third and fourth fingers are especially neglected, and when the pianist is serving his irksome apprenticeship at the keyboard, his first difficulty is the weakness of these fingers. It is months before he can use them to strike notes with anything like equality, and it is years before he can trill with them as he can with the first and second. This weakness should be remedied as far as possible, and the third and fourth fingers exercised until they acquire certain strength and precision of movement.

How to Strengthen the Hand.—There are various exercises for strengthening the muscles of the forearm and hand. In developing the muscles of the fingers it is important to exercise each finger separately, so that each will have independence of movement. The most convenient way of doing this is to use a table, or, better still, a spring grip dumb-bell, and press slowly and firmly upon it with each finger in turn, withdrawing the finger back again as far as possible to exercise its extension. The third and fourth fingers should especially be exercised in this way to give them perfect freedom of movement. Free movements, or movements without apparatus, are also valuable. Stretch out the arm, meet the forefinger tips with the point of the thumb, the tips pointing downward, now smartly supinate the hand and extend the fingers so that the open palm is uppermost. Repeat until tired. This is a general exercise. Also practice the fan movements of the fingers, opening and closing them till tired,—this will develop the interossei. Strength in the hands is more telling than strength in any other part, but it must be remembered that development of the muscles of the hand does not affect the delicacy of its movements. The whole muscular system of the hand is constructed with a view to swiftness and fineness of movement. In other parts of the body we find nature has many contrivances in the way of leverage to increase power at the expense of rapidity; but in the hand the end in view is speed and precision of movement, and the leverage is almost non-existent, so that while developing the muscles we greatly increase the strength—we do not impair the delicacy.

Effect of Exercise on the Hand.—Exercising the hands is especially valuable for those with whom the constant use of certain fingers in the same positions and movements has caused cramp or nervous twitchings. "Writer's cramp" and the many other diseases of the hand peculiar to certain trades and professions would be unknown if all its muscles received a reasonable amount of general exercise.

This is the one great object of physical culture,—namely, to avoid over-development of certain parts of the body and the starvation of others, occasioned by the extreme specialization of workmanship which civilization has brought upon us, and to strive for that general and ideal balance of development which alone means health.

The First Principles of Muscle Control.

A Simple Method of Developing the Body.—It is quite possible to develop the muscles, make them subservient to the will power, and bring about that coördination between brain, nerves and muscles known as "condition," without taking any violent exercise whatsoever. In fact, it may be done while sitting in a chair, lying on a couch or going about one's daily vocations. The advantage of this is obvious. Those whose occupations are sedentary, or who do not care about active exercise, can keep themselves fit and well by this means. But it must not be assumed from this that it is not fitted for the young and athletic. On the contrary, it is well worthy of acquisition, for it is really the basis of all physical culture, tending as it does toward that concentration of the will on the muscles which alone can bring about perfect development.

The Value of Muscle Training.—It simply consists of alternately flexing and relaxing all the chief muscles of the body in turn. All muscular development is the result of such movements, but whereas in most exercises they are involuntary, here they are conscious and spring from a direct effort of the will. And in this, apart from the beneficial effect they have upon the muscles themselves, lies their chief value. They constitute a splendid training of the will power, and after a very little experience it will be inevitably found how vastly susceptible this power is of being increased by cultivation.

Contractions Classified. — Contraction of the muscles may be divided into two classes: (1) the *contraction of endurance,* and (2) the *contraction of momentary power.* For purposes of illustration let us take the biceps, the large muscle, and what applies to it applies equally to any other of the voluntary muscles. Every one knows how to contract his biceps, the usual method being by flexing the forearm on the elbow and bringing the hand down toward the shoulder. This, however is not necessary, it being easy enough, after a little practice, to hold the arm still and alternately flex and relax the biceps merely by an effort of will, without moving the hand upward. When the biceps is contracted it is not sufficient to merely exert a large amount of physical force,—everything else must be forgotten for the time being, and the mind, as it were, projecting into that muscle.

The Contraction of Endurance.—The contraction of endurance is obtained by flexing the muscle in the manner described and keeping it tense as long as possible — in fact, until the muscle is absolutely tired out. Each time that this is done it will be found that it will be possible to retain the contraction for a longer period; in fact, it produces not only strength and development, but that valuable quality, *staying power.*

Contraction of Momentary Power. — What I have termed the contraction of momentary power is just the converse. The biceps is contracted as hard as possible and as quickly as possible, then rapidly relaxed, the alternate quick tension and relaxation being continued until the muscle is thoroughly tired. This is most useful in giving strength of the kind which is used in a momentary effort, such as in hitting a sharp, quick blow, in jumping, in turning a somersault. More valuable still, it imparts quickness and decision to brain as well as hand; by practicing it, it will be found that the rapidity with which intention can be translated is vastly increased. It strings up the nervous system, brain and hand work in complete harmony, and like a flash of lightning follows upon the intention to act, the act itself.

Brain Activity Measured by Muscular Activity.—If you wished to put to the test the relative quickness of two men's decision and speed of action, no better means of doing so could be devised than by a comparison of the speed with which they contract their muscles. A delicate instrument could be placed in communication with their biceps, for instance, and the record of the rapidity with which the muscle was shot up to the fullest capacity and allowed to relax would furnish an exact comparison of the two men's rapidity of converting thought into action and of the action itself.

The Value of Developing Brain and Muscle.—In connection with this there is a factor which must not be overlooked. It illustrates the importance and the advantage of symmetrical and all-round development. For if all the muscles be exercised in this manner, they will all be equally obedient to the mandate of the brain; the nerves will be equally quick in communicating the message from the brain, and the equally trained muscles will act with equal readiness. Hence the necessity for symmetrical and all-round development. Without it, however well developed certain muscles may be, action will inevitably be slow, for in the cases of some muscles the nerves will only communicate the intention tardily, and when communicated, the power to act upon it being likewise untrained, the resulting action will also be labored and deliberate.

Muscular Control Gained by Practice. — The majority of people, being, to start with, unequally developed, will experience for a time considerable difficulty in persuading the less exercised muscles to respond to the will; but let them persevere, and they will find that, slowly but surely, the recreant nerves and muscles will in the end have to bow to the dominant power. The great thing to bear in mind is to practice the habit of concentrating the mind upon the particular part which is to be called into play. With continual practice the habit will become second nature, until at last any muscle can be contracted to the greatest pitch of hardness without difficulty.

How to Contract a Muscle.—And now comes the all-important question, "How am I to contract my muscles?" I shall proceed to deal *seriatim* with the principal groups, and by paying a little attention, even those to whom anatomy is a sealed book should have little difficulty in acquiring a complete mastery of this important branch of physical culture. It will well repay attention, as, once thoroughly mastered, it will prove an invaluable aid in subsequent exercises. The learner must not be discouraged if he finds the process of getting his muscles thoroughly under control rather a slow one; let him persevere, and he may rest assured that success will ultimately be his.

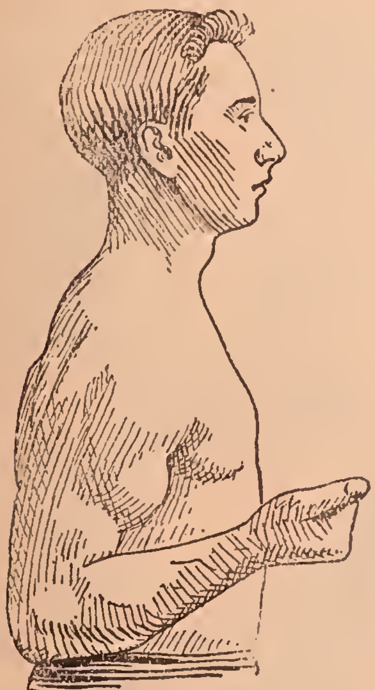


FIG. 1. Biceps.

The Arm.

Biceps and Triceps.—(Figs. 1, 2, 3.) While seated in chair, place the hand lightly on the thigh, the arm slightly bent, and, without clenching the fist or raising the arm, by a strenuous effort of will tighten up the biceps. In this position, by making tense the biceps, the triceps, or muscle at the back of the arm, is also contracted, and the maximum of contraction of both together is obtained when the forearm is brought up until it is nearly, but not quite, at right angles with the upper arm, and the latter is forced well back. By allowing the forearm to flex upon the upper arm the biceps alone is contracted and the triceps remain limp, while by straightening the whole arm downward and backward the contraction of the triceps is alone obtained. The best method is to contract both together, as already explained, with the hand resting open upon the thigh and the elbow slightly bent. At first assistance may be gained by pressing the arm against the body, but afterward, when some amount of control has been gained, this must be discontinued and the tension obtained solely by will-power acting upon the particular muscles it is sought to control. At first the contraction should be sustained as long as possible, and not until afterward should the contraction of "mo-

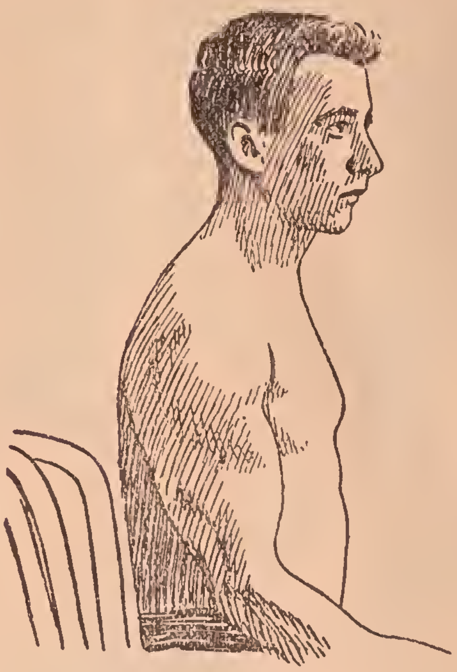


FIG. 2. Biceps and Triceps.

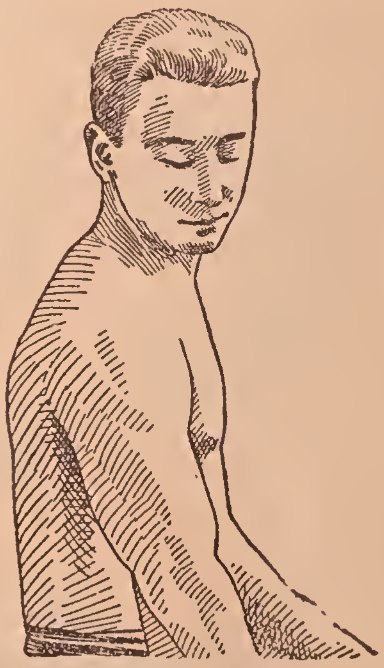


FIG. 3. Triceps.

mentary power" be practiced. This holds good not only with the muscles of the arm, but with all the others.

Forearm.—(Fig. 4.) The contraction of the muscles of the forearm is easily explained and put into practice. The forearm muscles are chiefly used in gripping, the muscles of the hand being mainly applied in moving the fingers laterally. Consequently, to contract the forearm muscles, the arm may be held in the same position as described above, but the fist must be clenched. The alternate tension and relaxation of the muscles is obtained by flexing the hand upon the wrist, and this should be done in every direction, so as to secure mobility and to bring into play all the different groups of muscles lying on the inside and outside of the forearm. In addition to their action upon the forearm, these exercises are very beneficial to the wrist, as they tend to increase its strength and mobility.

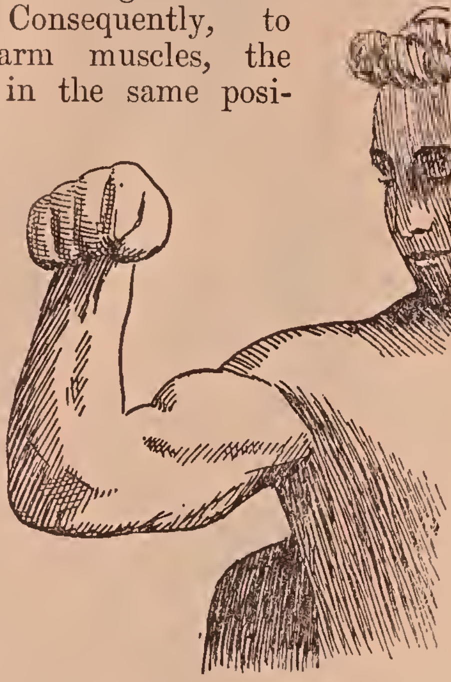


Fig. 4. Forearm Muscles.

The Leg.

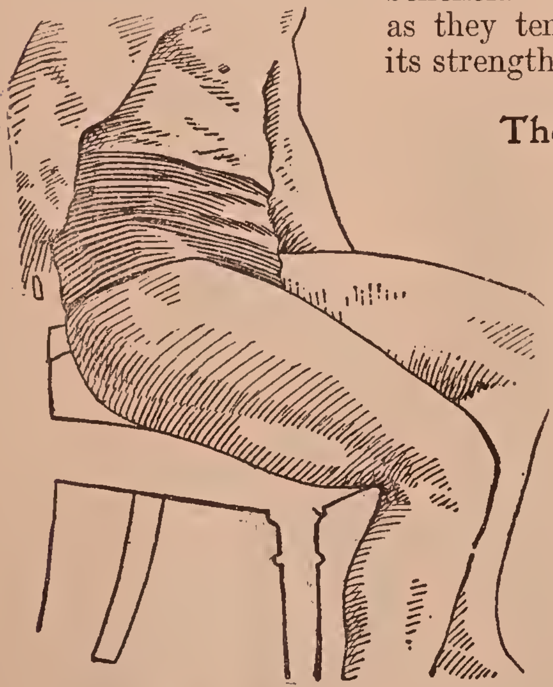


Fig. 5. Biceps of the Leg.

Biceps.—(Fig. 5.) There is this peculiarity about the biceps, or great muscle running down the back of the thigh—that it cannot be contracted without also contracting the greater part of the quarterseps on the opposite side of the thigh. The converse is, however, not the case, for the quarterseps, as we shall presently see, can be contracted by themselves. To contract the biceps of the leg (and necessarily the quarterseps as well), sit forward on the chair and bring the feet (which should rest flat on the ground) well under the knees. The biceps can then be alternately contracted and relaxed with ease. It will be noticed that in this exercise the calves are also brought into play.

Quarterseps.—(Fig. 6.) To contract the quarterseps alone is very simple, it being only necessary to reach out straight with the legs to their fullest extent. These constitute a very important group of muscles, and too much attention cannot be given to their development.

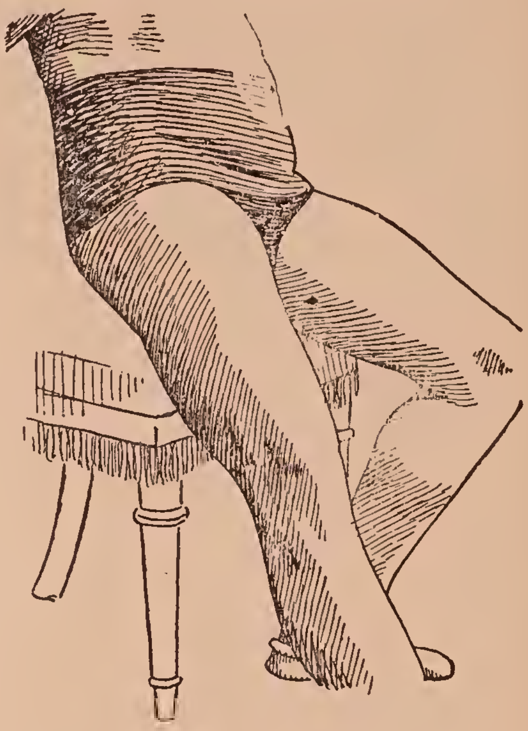


Fig. 6. Quarterseps.

Calf and Shin Muscles.—(Fig. 7.) This exercise requires a good deal of practice before it can be properly performed. Sit well forward on the edge of the chair, and, keeping the feet flat on the ground and the knees unbent, stretch out the legs to their fullest extent. At first it will probably be found very difficult, if not impossible, to keep the knees straight while the feet remain flat, and for a time it may be necessary to slightly bend the knees. Shortly the muscles will become more flexible, and every time the exercise is performed an attempt should be made to get the legs a little straighter. This

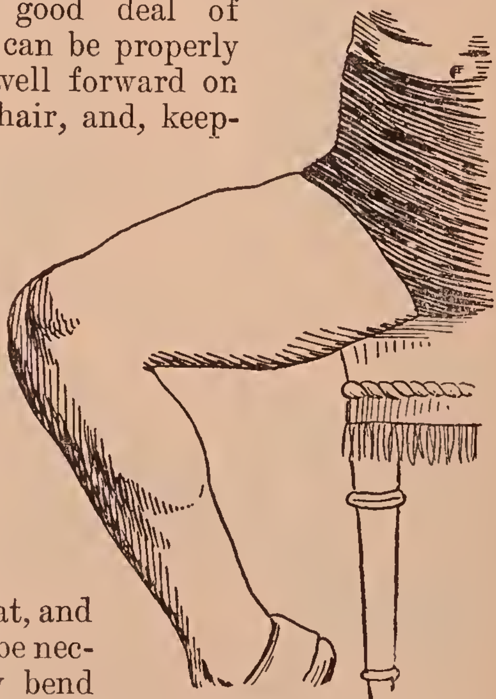


Fig. 7. Calf.

exercise chiefly affects the stretching muscle of the calf. To exercise the pulling-up muscles, the knees should be bent and the feet brought up under the body, with only the toes pressing upon the floor. By sitting in the same position, resting the heels on the ground and raising the toes, the muscles on the front of the shin, chiefly used in riding and walking, are brought into use.

The Muscles of the Trunk.

The Pectorals and Latissimus Dorsi.—(Figs. 8, 9.) To contract the pectorals, or breast muscles, place the hand on the thigh and press the shoulder down. This will contract the pectoral muscle on the same side, with or without the contraction of the latissimus dorsi, or great muscle of the back, which extends from the waist to each shoulder, according to the position of the arm. By placing the arm farther back, the latissimus dorsi may be contracted without the pectoral muscles being affected. It is rather difficult to describe the exact position of the arm. The learner must practice assiduously, and should be greatly aided by a careful study of the illustrations. The latissimus dorsi on both sides may be contracted laterally by getting the arms well back and holding them slightly out from the body; then raise the shoulders by using the back muscles. The arms must be allowed to hang quite limp, and in order to bring out the latissimus to its fullest extent the lifting motion of the shoulders must not be assisted by the muscles of the neck and shoulders.

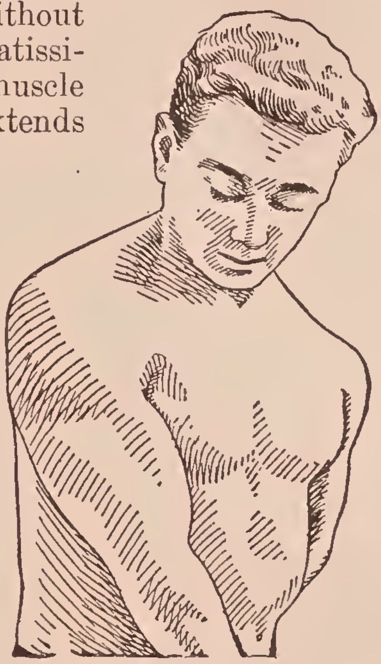


Fig. 8. Pectorals.

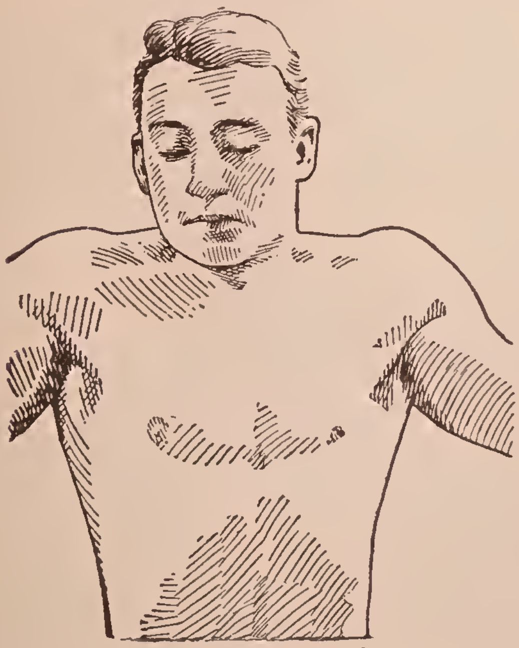


Fig. 9. Expansion of Chest; bringing out Latissimus Dorsi.

The Serratus Magnus.—(Fig. 10.) This muscle, which lies over the ribs, may be contracted by the same means as employed with the pectorals, only the arm should be held a little farther out from the body. This is the muscle which braces the shoulders forward. If it were not for it, when we push, the shoulder would fall around back. It is, consequently (together with the pectorals and anterior deltoid), the muscle used in striking a blow from the shoulder.

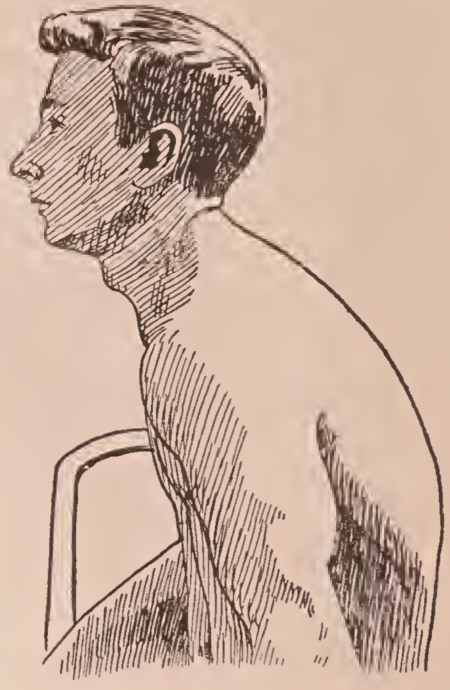


Fig. 10. Pectorals, Latissimus and Serratus Magnus.

The Deltoid. — (Fig. 11.) This is the muscle which caps each shoulder and the top of the arm. To contract it, place the hand on the thigh and endeavor at the same time to force the elbow up and the bone of the shoulder down, so as to produce a hollow just below the bend of the shoulder. This muscle gives the necessary fullness to the shoulder, giving the broad effect.

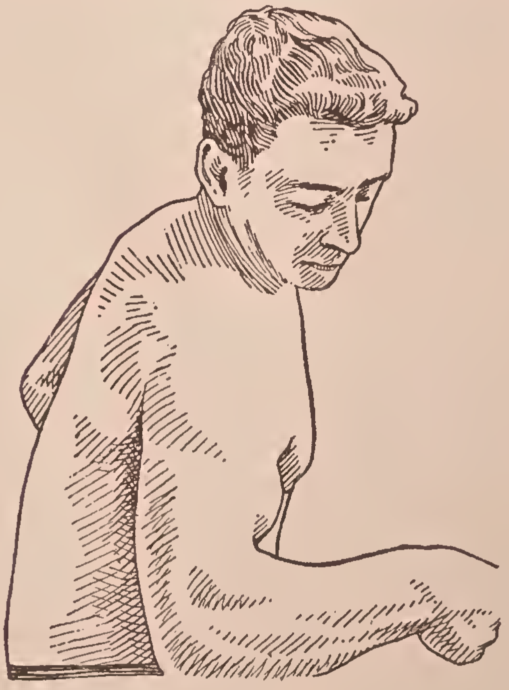


Fig. 11. Deltoid.

The Trapezius, or Collar-Bone Muscle. — (Fig. 12.) This is very easily contracted by placing the arm a little back and humping the shoulders and endeavoring to force the neck into them. Its actions are to draw back the head, to lift the shoulders or brace them back and upward.

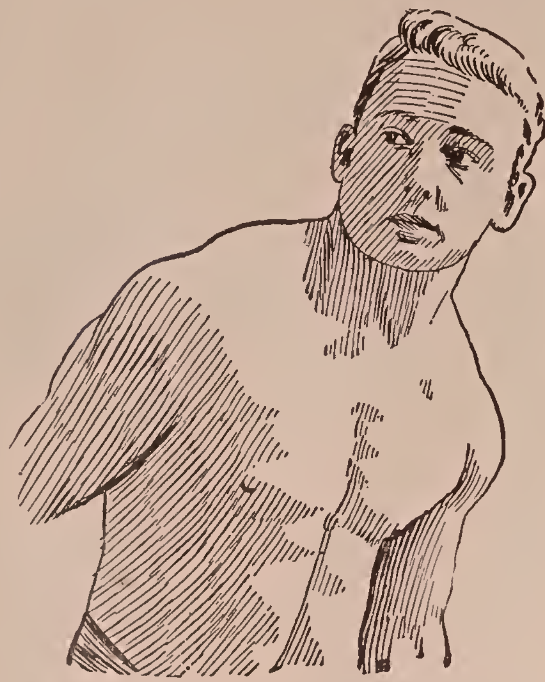


Fig. 12. Trapezius or Collar-Bone Muscle.

Abdominal and Groin Muscles. — (Fig. 13.) All those who wish to engage in feats of activity and strength should pay the very greatest attention to these muscles, which are all too frequently neglected. In many sports and exercises the strain upon them is very great, and unless they are properly trained they are apt to give way, and rupture and other serious internal injuries be the result. Both abdominal and groin muscles are contracted and, of course, developed by the same means. Seated in a chair, slightly contract the chest and endeavor to force the muscles which extend across the body from the point where the ribs part to the abdomen downward. Don't push the stomach outward, but try to make the movement entirely perpendicular. This will also contract the muscles of the groins, as at once will be noticed.

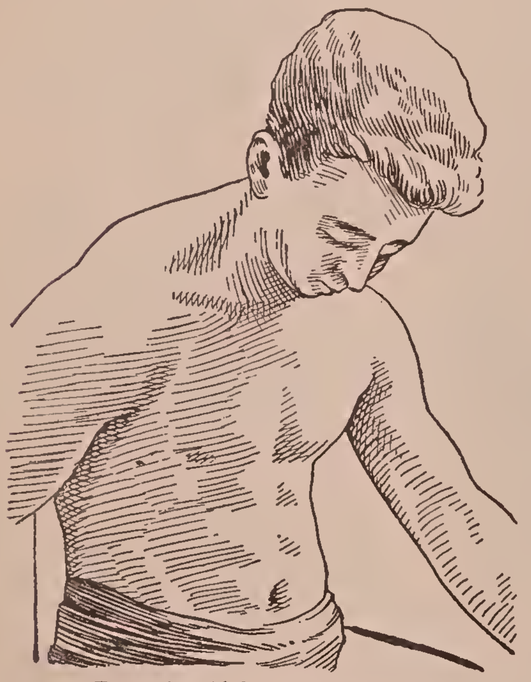


Fig. 13. Abdominal Muscles.
These also Contract Muscles of the Groin.

Where and When to Practice. — In the foregoing only the principal muscles have been dealt with; but when once the learner has thoroughly got them under control, he should have small difficulty in applying what he has learned to any of the smaller and less important groups. The contraction for endurance of the arms and legs can easily be done, without attracting attention, while taking a constitutional on foot or while riding a bicycle; but it would be advisable not to attempt to do the quick momentary exercise in public, as one might run the risk of being mistaken for a wandering lunatic and promptly arrested. But the slow, continued contractions can be done unnoticed.

A Caution as to Contraction. — In connection with the contraction of the muscles, I have, in conclusion, to give a word or two of advice. Do not, especially where the muscles of the trunk are concerned, contract the muscles of both sides at once, as that entails a certain amount of strain upon the heart and the breathing apparatus. Don't be afraid to put all you know into the exercises, and if you allow one side to rest while the other is working, you need have no fear of straining or otherwise injuring yourself. Finally, when you contract a muscle, don't allow your breathing to become restricted. The natural tendency at first is to hold the breath, but this must be overcome and a habit of free and natural breathing cultivated. Do not be disheartened because your progress at first seems slow; nothing worth having is to be gained without labor. I can only tell you what to do—only point out to you the right road. The rest lies with yourself. There is no royal road to success. Your reward lies not so much in the accomplishment as in the effort and struggle and all the good qualities which they bring out.

Deep Breathing.

"I die content," said the great Sydenham, the father of English medicine, when on his deathbed, "for I leave behind me two great physicians—fresh air and exercise."

Breathing Should be Natural.—It is no more necessary to teach a child to breathe than it is to give such instructions to a dumb brute. The child breathes naturally and instinctively, but the majority of civilized adults have lost the art of breathing. By wrong habits of dress and by incorrect attitudes they have so crippled their organs of respiration that the most important and vital function of the entire body is rarely, if ever, correctly and fully performed.

Description of Improper Breathing. — The majority of people, when asked to fill the lungs, make an unnatural and strained effort of some kind. Many, especially women, elevate the shoulders—raise the collar bone to expand the upper part of the chest a little, exhibiting the type of erroneous breathing known as collar-bone respiration. Others, having learned something of the evils of this form of breathing, cultivate the opposite error, represented in abdominal breathing, in which the respiration is carried on almost wholly by means of the diaphragm. The diaphragm is forced downward to the utmost extent, the lower abdomen being forced upward to a corresponding degree. The effect of this is to cause downward displacement of the liver, stomach, kidneys and colon. Strictly speaking, abdominal respiration, then, is no more natural or normal than exclusive costal breathing.

One-Sided Breathing.—We sometimes find people who breathe chiefly with one side of the chest, perhaps as a result of an obstruction of one of the nostrils corresponding to the inactive part of the chest. This may also be due to the loss of the physiological reflex action which takes place between the nostril and the breathing apparatus. One-sided breathing is frequently practiced by people suffering from nasal catarrh. The air which enters one nostril brings into play only one side of the chest. Each side of the lungs is controlled by the pneumogastric nerves, one going to either side. The nose is so connected with these nerves that the air entering one nostril excites and brings into play the muscles which control the opposite side of the chest. I am inclined to think that many people afflicted with catarrh breathe through the mouth not because they cannot get air enough through one nostril, but because the air entering through one nostril affects only one side of the chest, and the breathing through the mouth is an unconscious, natural effort to breathe with the whole chest.

Nasal Breathing.—The mouth should form no part of the respiratory tract. The nose is the natural passage for the air, as in passing through the nasal openings the air is both filtered and warmed. There is nothing more simple to acquire than the habit of nasal breathing. It only requires practice. Do all of your breathing exercises with the mouth shut, and no matter how uncomfortable it is at first, in a few days it will be less uncomfortable, and in a week or two you will notice no inconvenience, and even in your sleep you will rest naturally with the mouth shut.

The Proper Way to Breathe.—In children and savages, and in long-distance runners and men who have been accustomed to fast walking, also in the lower species of animals, we find a different kind of breathing—waist breathing, or lower chest respiration. This is the natural mode of breathing. Observations upon animals, young people and normal adults show that natural and full respiration involves the expansion of the entire trunk, and is a waist expansion rather than expansion at either end of the trunk. Remembering the construction of the skeleton, you will readily see the reason for this. You will remember that the first seven ribs are attached directly to the breastbone, while the lower five are not so attached, but leave an open triangular space in front of the lower half of the chest. In other words, in the upper part of the chest the circle formed by the ribs and the spinal column is completed by the sternum, while in the lower part the anterior wall is left incomplete, affording a uniform V-shaped opening between the ribs. This is evidently for the purpose of giving greater mobility to the lower part of the chest. We find further evidence of this purpose in the attachment of large, strong muscles to the ribs along the sides, so divided and attached to each rib that the muscles take hold of the ribs individually in the most vigorous manner. In normal breathing, therefore, any great degree of downward movement of the stomach, liver, kidneys and other viscera is prevented by an expansion of the trunk at the waist.

A Mechanical Illustration.—In natural breathing we have precisely the same action as that of a pair of bellows. The chest corresponds to the bellows, the trachea to the nozzle, the ribs to the handles, and the muscles to the personal force applied to the handles. How absurd it would be to attempt to expand a pair of bellows by seizing them at the nozzle, or near the nozzle, and trying to work the handles in or out. Yet that is precisely what we do when we undertake to breathe with the upper part of the chest alone. Such breathing, or collar-bone respiration, is like tying up the handles of the bellows and then attempting to operate them by seizing the sides and trying to force them in and out. Unfortunately, the majority of civilized women are compelled to breathe in just this way, with the handles of the bellows tied up, so to speak.

How to Take a Full Breath.—To take a full, deep breath, expand first the chest, breathing in until the entire waist swells out, the sides expand and the anterior walls expand. Then breathe in a little more, until the whole abdomen expands. Then try to inhale still more by lifting the chest and drawing the lower part of the abdominal wall in slightly. This gives a full and complete respiration. The lower chest is filled, the diaphragm is well brought up, the upper part of the chest is strongly lifted. This strong lifting of the chest at the end of each inhalation is one of the best means of aiding the restoration of prolapsed viscera to their normal position, and has the double effect of increasing the negative pressure within the chest and the positive pressure within the abdomen, thus not only helping to draw the viscera into position, but also materially aiding the portal circulation. Few people know that deep breathing will bring the body to a glow even in the coldest weather. This is due to two causes: (1) the more perfect oxygenation of the blood, and (2) the strengthening effect of the heart's action. This is a useful thing to remember on a cold day, when you do not wish to excite attention by stamping the feet.

Value of Deep Breathing.—Let us see what is accomplished in taking a long breath. Ordinarily you breathe thirty cubic inches of air with each inspiration. By a very deep inspiration, as deep as you can make it, you inhale an additional one hundred cubic inches, making one hundred and thirty in all. By a complete expiration you can send out one hundred cubic inches of air beyond the usual thirty, making one hundred and thirty in all. In addition to this you have left in your chest one hundred inches of air, called by physiologists "residual air," which remains even after the most complete expiration. From this it will be seen that, instead of the ordinary sixty inches of air, you may inhale and exhale two hundred and sixty cubic inches at each respiration by practicing deep breathing, or over four times as much as under ordinary circumstances. By this means the blood is thoroughly purified and fully stored with oxygen, and the lungs, that have lain asleep for years, closed to everything but disease, are suddenly awakened into splendid life.

Effects of Deep Breathing.—Muscular action is followed by important chemical changes, the two chief products being carbonic acid and sarcolactic acid. These must be disposed of or the muscle will die from poison. If you have ever seen a hare run to death, you will know that it becomes stiff in a few minutes, and that the flesh or muscle becomes putrid in an hour or two. This is because the poisons formed by the muscular action accumulated more rapidly in the tissues than the system could get rid of them, and the hare actually died from poison.

The breathlessness which we experience at first during exercise, and more especially exercise bringing into play the great muscles of the thigh, as in running, is due to the fact that the carbonic acid is being formed more rapidly than the lungs can stay it over. As the lungs deepen, and as the circulation improves, breathlessness does not result so quickly from muscular action, simply because the system is able to cope with the increase of combustion of its poisonous products. The stiffness experienced a day or two after exercise is caused not by the presence of carbonic acid in the tissues, but by the existence of sarcolactic acid. This stiffness always wears off after a few days' exercising, because, just as in the case of the carbonic acid, the system has become better able to eliminate it. It will be seen that the capacity for muscular exertion depends to a very great extent on the soundness of heart and lungs which the individual possesses, for deep breathing exercise has the effect of facilitating the venous circulation in the chest and of assisting the heart in the effective circulation of the blood. When a deep inhalation is being taken, for example, there is a suction in the chest cavity and the blood is drawn from the great veins into the upper heart. On expelling the air the lower heart is greatly assisted by the increased pressure in driving the blood to the lungs and into the aorta.

Development of the Chest.

Importance of Chest Development.—I now intend to show the importance of chest development and how it may be obtained. From the standpoint of health there is nothing of so much importance in this country, where lung disease is so prevalent, as the development of the chest. It is astonishing how few one meets with arched chests, although the arched chest has always been considered the symbol of manliness. This is doubtless due to the fact that in men the clothing is suspended from the shoulders and the weight of it falls upon the chest, compressing, be it ever so little, the natural arch, and thus distinctly tending by the continuous pressure to make the chest flat. Every one should be able to show a difference of from three to five inches between the chest contracted and the chest expanded. The development of the chest should be watched, as nearly all occupations tend to curve the spine and cramp the chest. Men almost universally bend over their work, and this disposition should be corrected by exercise. By keeping the neck pressed back the arch of the chest must be raised and the stomach drawn in.

Any weakness or deficiency in the chest is made apparent in every effort, whether mental or physical. When one is about to make a physical effort he first takes a deep breath, and then fixes the expansion of the chest by closing the glottis and thus preventing the air from escaping. The abdominal muscles are powerfully contracted, fixing the diaphragm and making the thorax for the time being a solid mass, from which the muscles can act with force and precision. In this way the pressure within the chest is enormously increased. Indeed, it is so great as to compress the great veins of the heart and to temporarily stop the venous circulation. In consequence, the veins of the neck become distended, the face swollen, the eyes start out. The heart may even cease beating for the moment, and in one who has not been prepared by systematic exercise for such a strain serious results may follow, such as injection of the venous capillaries, or even rupture of a vein. It does not matter what caused the effort,—it may be in lifting a heavy weight, or, as has been well said, in using great force to crack a nut between the fingers—the physiological consequences are the same.

The Chest Wall Must be Deepened.—If you have not previously practiced deep breathing, you will find, on attempting to expand your lungs fully, that the chest will act as a dead resistance. This resistance of the chest wall is the cause of people becoming "puffed" in running to catch a car or train. The lungs in this instance, not being fully developed, form the first obstacle to the capacious breathing demanded by the rapid exercise; and in the second place, even if the lungs had the power to expand, the rigid structure—the undeveloped chest wall—would hamper their expansion. Thus, in addition to practicing deep breathing, special and careful study should be given to the development of the chest wall. By so doing you relieve the pressure on the lungs and enable them to expand without resistance. In addition, you secure that mobility and prominence of chest which are so remarkable among our leading singers. The secret in securing this mobility lies in expanding the chest by muscular effort. This develops the intercostal muscles, the serratus and the muscles of the neck—all concerned in forcible inspiration and in raising and maintaining the arch of the chest.

Cause and Cure of Lung Disease.—In the average man or woman there are myriads of air cells which are collapsed and are never filled with air except under systematic breathing exercises, and this is partly the reason why breathing exercises are followed by such an increase in the chest measurement. So, in a person of weak lungs, if the lung tissue is developed and increased in extent and capacity, there is every chance that the tissue, which before was so weak and ill-developed as to offer a happy hunting ground for the tubercle bacillus, will be able to resist any attack from that quarter. In cases where extensive ravages have been made by this all-present microbe, it is absolutely the fact that the renewed vital energy and increased lung capacity brought about by breathing exercises will certainly help, and if the case is not quite hopeless, probably succeed in restoring the lungs to a healthy condition, the diseased part becoming gradually absorbed until a mere cicatrix is left. It is obvious that if the lung tissue is greatly increased such a thing as a cavity in the lungs can hardly exist. I have had innumerable cases at my schools and privately in which lung disease has been totally cured and the pupil restored to a state of health and vigor. Lung disease is simply caused by two conditions—deficient exercise of the lungs, or exercise in foul and unhealthy atmosphere, or by deficient vital energy.

Medical Exercises and Their Field.

Remedial Exercise.—I shall now discuss the exact field of medical exercises, or "remedial" exercises, as they are termed professionally, and show how they may be beneficially applied. All good things suffer from exaggeration of their virtues. The moment any drug is recommended as a panacea—a cure-all—it becomes degraded to quackery; and I am afraid that exercise has suffered to some extent by the vague and general manner in which it has been recommended for every ailment under the sun. No such thing exists in nature as a universal remedy, and it is unwise in the highest degree to exalt any remedial measure to such an extent.

Function Makes Structure. — First discussing the question from a general point of view, I must remind you that the exercise of any faculty is necessary to the retention and development of that faculty. The use of any function brings improvement and perfection; its disuse brings degeneration and decay. For instance, if we desire to increase the structure of the heart, we prescribe gradually progressive exercises which create a greater demand on the heart, with the result that it is gradually built up to meet this increased demand. If the muscles of any part of the body are deficient we prescribe exercise that demands the use of those muscles, and growth follows at once. Whenever we desire to increase structure we increase the function of the parts. This general law applies to the development of all forms of tissue as well as to muscle-tissue.

For this reason Nature gives the instinct for unconscious exercise. The love of play and recreation develops the physical powers. Existence itself demands continual exercise of the mental powers, and the problems of life are quite sufficient and mysterious to exercise from day to day the moral faculties.

Primitive Importance of Organic Strength.— Now, in the days not so long past, the strength of the arm was the only means of winning the daily bread or of achieving ambition; in other words, the struggle for existence depended directly upon the physical strength of the individual. It has ever been the instinct of the herd to fall upon the stricken hind, and, before the advent of law and civilization, weakness meant contemptible insignificance, if not worse. But the more bitterly the physically weak were oppressed, the more keenly did their minds, made preternaturally acute by necessity, devise fresh means for annulling the immediate powers of physical strength. The pendulum threatened to swing in another direction. Mind seemed to become the controlling power.

The Value of Systematic Exercise.—When we have seen two extremes, it is easy to strike the natural medium. As physical strength alone would rank men with the brutes, so mental activity without bodily health soon becomes pathological. The tendency of the day, of course, is to take less and less exercise, partly because of want of time, partly because of facilities for rapid transit. Now, of course this denial of bodily activity invites physical degeneration. Consequently, where environment does not permit of sufficient natural means for exercise, artificial means must be resorted to. Therein lies the value of systematic exercise, because it occupies little time, can be adapted to the convenience of the individual and his surroundings, is immediately invigorating and refreshing, and is a distinct addition to the permanent strength.

The Scope of Medical Exercises. — Physiologically speaking, exercise is universally beneficial. That is to say, it increases health and energy and has a beneficial effect upon every tissue. But it would not be wise to argue that, because of this, medical exercise constitutes a cure for all diseases. In the first place, all acute disorders fall outside the scope of medical exercises; the field rather confines itself to sub-acute or chronic disorders.

Disorders Benefited by Exercise.—To take deformities in the first place, of course nearly every muscular deformity can be cured by exercise; especially is this so in the case of lateral curvature, where certain muscles become weaker and weaker while the opposing muscles become stronger, thus rapidly increasing the vicious habit of the curvature. Another muscular group is that of bad development or under-development. Take, for example, the case in which the muscles of one limb have atrophied in consequence of some congenital defect. This can be easily cured. The third group is that associated with nervous disorders, such as wry neck, writer's cramp, paralysis, etc. In the case of paralysis the scope of exercise would be much clearer if the following point were quite understood: Where there is a possibility of exercising will-power it should be used. Some kinds of paralysis are so advanced that the sufferer has lost the power of conscious movement. These cases, of course, must be treated with hand massage or electricity. However, where movement exists in even a slight degree, immeasurably better results will follow if actual exercise, accompanied with the use of the will-power, be employed in connection with massage. That is to say, the more severe the paralysis, the more we must fall back upon hand massage and electricity; the less severe it is, the more we must employ movement massage, resistive movements and voluntary exercises. Another muscular group is that associated with bony deformity. Into this group fall clubfoot, knock-knees, the several kinds of curvature, many ricketty deformities, etc. These require very careful and special treatment.

Organic Complaints.—Leaving muscular disorders, we come to organic complaints, in which the great arteries are more or less diseased. It is of course difficult for me to treat in a free and full manner these subjects in a few pages which are not intended to be professional, and for this reason medical readers must pardon the slightness of my remarks, and must in most cases excuse the indication given instead of a description. Before entering upon the subject I should like to point out the danger of exercise in certain cases. In the first place, exercise should never be prescribed by an incompetent man. For this reason, if there is any doubt, a medical man should be consulted. It may be said, however, that many conditions exist which are generally supposed to make exercise dangerous, but which are, as a matter of fact, improved thereby. Taking three of these, I may mention the cases of rupture, of varicose veins and of heart disease.

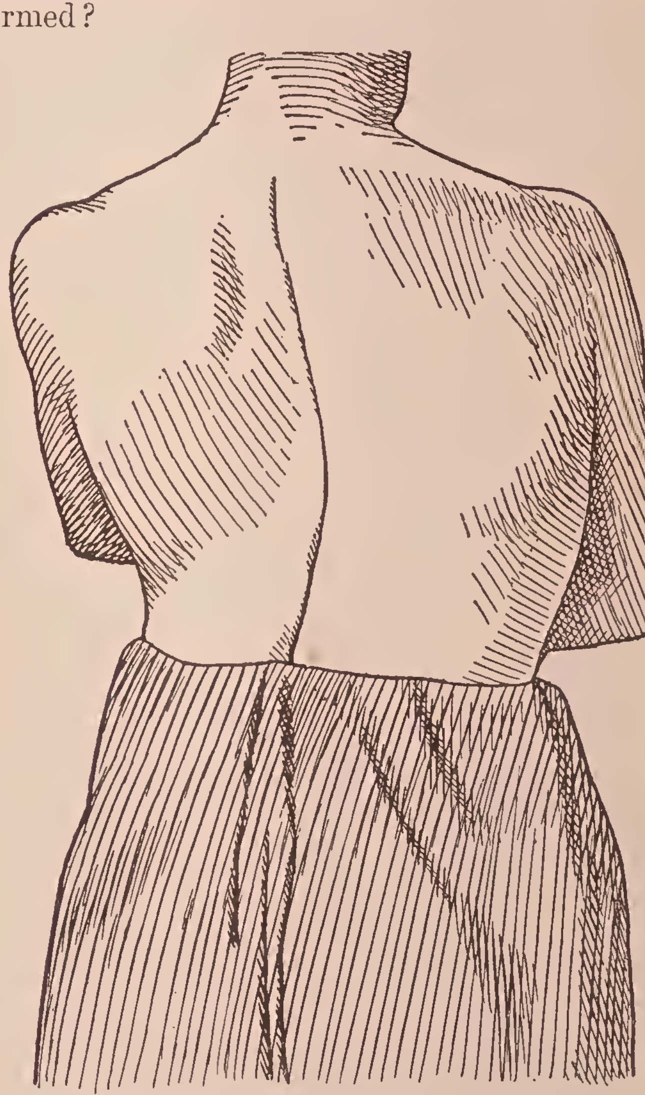
Rupture.—In the case of rupture, providing a truss is worn while exercising, exercise may be taken without danger and with distinct benefit. As a preventive of rupture, exercise is infallible. For varicose veins, although no cure exists except operation, some authorities are quite decided that the effect of exercise upon them is rather beneficial than otherwise.

Heart Affections. — Heart affections fall into two classes—one where actual disease is not present, the other where the valves are affected. The heart, let it be remembered, is a muscle, consisting of about seven layers of fibers running in different directions, but nevertheless one muscle, and by development of the muscular system generally it is undoubtedly the case that the muscular tissue of the heart is both strengthened and increased, so that nothing can be better in the case of a weak heart in which the valves themselves are not diseased, than gentle exercise, gradually increased as the patient grows stronger. While the first condition can generally be absolutely cured by exercise, the second condition can also be considerably ameliorated.

Nervousness, Pulmonary Disorders, etc. — The three great organic groups for which exercise is a sovereign remedy are, first, nervous disorders; second, lung disease; third, ailments which have as their cause abdominal congestion. In the first group are included all kinds of nervous prostrations or disorders. In the second, of course, the case resolves itself into that scourge of civilization —consumption. I am convinced that exercise, combined with the taking of cod-liver oil, will be an effective cure, except in the last stages. The third group, or abdominal disorders, includes congestion of the liver or sluggish liver, constipation and its attendant train of evils—indigestion in its many forms, hemorrhoids, etc. All of these may be cured by following properly prescribed exercises.

Lateral Curvature.

Now to take up a few of the common muscular deformities. First comes lateral curvature and also the slighter forms of paralysis. Lateral curvature I shall take first, because it is an entirely new field for scientific exercise. True, exercise of some sort has for some time been associated with the supposed cure, but so ignorantly that I imagine more harm than good has resulted. The cure of lateral curvature by exercise has become a science as solid and rigid as the books of Euclid. What is Lateral Curvature, or Scoloisos, as it is medically termed?

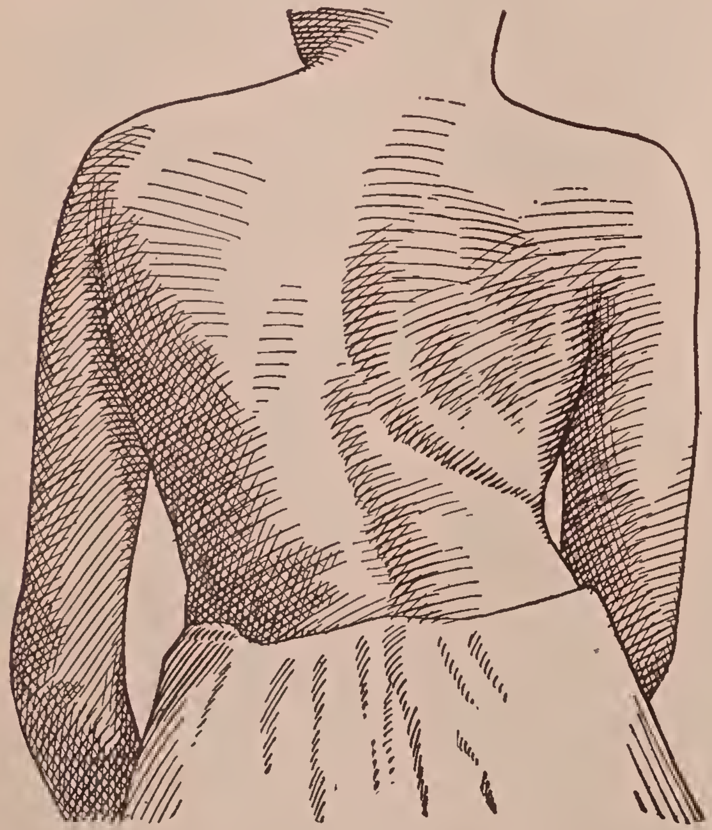


Case 1. Lateral Curvature in a Young Man.

Definition of Lateral Curvature.—Lateral curvature is a rapidly progressive deformity caused by bad positions in standing or sitting, where the spine is laterally curved, one shoulder drooped forward, the lower part of the chest cramped and twisted, usually with the protuberant side pushed backward and the hollow side inclined forward. There is thus not merely a lateral curvature, but also a rotary distortion. In the infant the spine is almost straight; but when the child begins to stand and walk the weight of the head and of the supported parts of the body cause curvatures which are natural and physiological—viz., curvature forward in the neck, backward in the shoulders and forward in the region of the loins. If any tissue weakness be present, these curvatures will be exaggerated. If any bony disease be present, the curvatures will probably become greatly exaggerated, an increase of the curvature backward being called *kyphosis, spondylitis* or humpback; an increase in the curvature forward being called *lordosis* or saddleback. These two conditions can only be dealt with by special jackets, and even then only with vague and unsatisfactory results.

Classes of Curvature.—Speaking broadly, curvatures may be divided, in point of severity, into three classes:

First. Lateral curvature in persons otherwise strong and healthy, brought about by excessive use of the right arm, faulty positions in sitting or standing.



Case 2. Lateral Curvature. (Back View.)

Second. Similar to the above, but an exaggerated form of it, owing to constitutional weakness or general weakness of the bone from malnutrition, as in rickets.

Third. Lateral curvature where there is a local inflammation of the spine.

The first group is easy to deal with, the second difficult, and the third renders necessary the use of the jacket. I shall now take up the various theories which have been set forth regarding lateral curvature:

Eulenberg. Eulenberg forms a theory as follows: Equality of the muscles on either side of the spine is necessary to keep it in an erect position. Curvature is therefore caused when the balance of power between the muscles on either side becomes disturbed, producing convexity on the side of the weaker muscles. He indicates a great frequency of curvatures where the convexity of the curvature is to the left, thus admitting the explanation based on the excessive use of the right hand and arm and the consequent greater development of the muscles extending between the shoulder and the thigh of the right side. This theory contains a certain amount of truth, and, undoubtedly, excessive use of the *right hand,* and the carrying of infants in such a position as to leave only the *left hand* free, has some bearing on the question, for on the convex side of a curve the muscles are stretched and weakened, while on the concave side the muscles become shortened, thickened and strengthened.

Dittel. Dittel regards the changes in the muscles as secondary, depending upon the inactivity and atrophy caused by the rigidity of the spine, and says that these muscular changes are observed only in curvatures of old standing. This view also contains a certain amount of truth, but does not cover the ground.

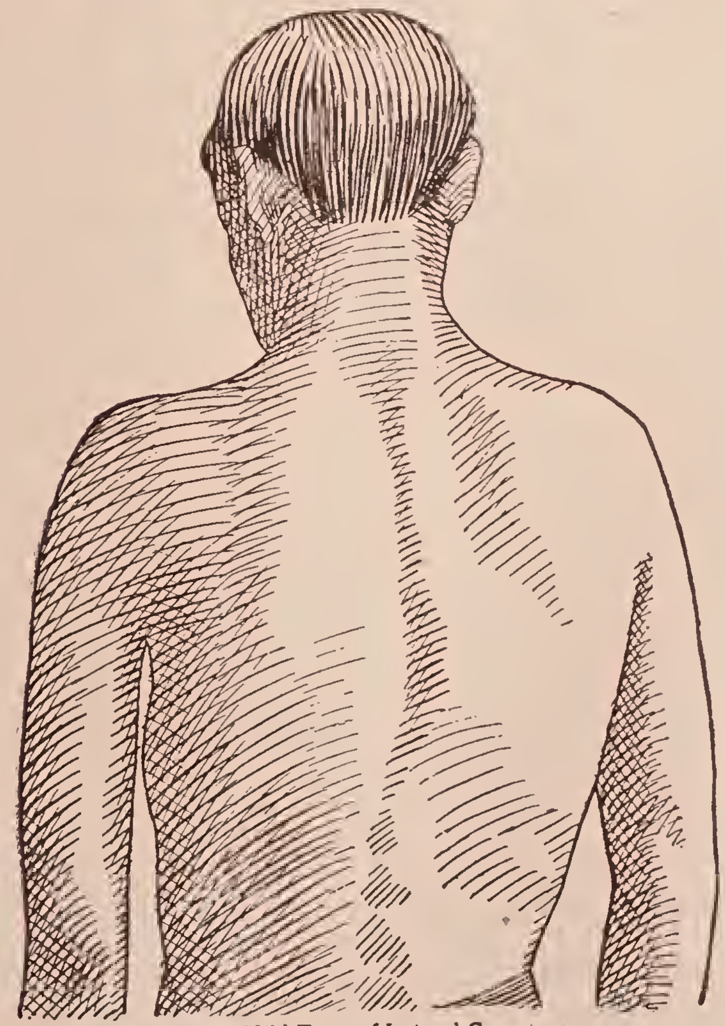
Guerin. Guerin noticed that the muscles on the concave side were put into a permanent state of contraction. This fact we have already demonstrated.

Malgaigne. Malgaigne believed that the curvature was based on the stretching of the ligaments on the convex side. This, of course, is often present, but it would be idle to look upon it as the cause.

Lorisser. Lorisser believed that the cause was due to the inflammation of the bone. I believe that this is only the cause in the graver cases.

The Static Theory. The static theory explains the curvature as being due to the habit of resting the weight of the body on one leg, say the right one, thus tending to produce a lateral curvature of the spine similar in shape to the ante-posterior curvature, which is natural. This I believe is the cause of nearly all curvatures, for nearly every case of lateral curvature has its beginning in a bad position of standing or sitting assumed in childhood. The standing position is the one which seems to be universally called the "stand-at-ease" position. This position may be described as follows: Right foot back, knee straight, left foot advanced, knee bent, the weight of the body being thrown upon the right foot. I understand that in army circles this position will soon be altered. The new "stand-at-ease" position will be: Feet apart, in the same line, hands clasped behind the back. This I consider a great improvement in every way, since it is in reality a much easier position and also insures the weight of the body being thrown upon both feet.

Effects of Improper Positions. — Every teacher should make a note of this and apply it in the training of boys and girls in their charge. If the weight of the body is thrown upon one leg, the line of the hips, instead of being level, is tilted at an angle, necessarily causing a curvature of the spine. In the usual sitting position a sort of spiral curvature is necessary to write or read with comfort. I might remark that in some of the cases which have come under my notice there has been an element of heredity.



Case 3. Mild Form of Lateral Curvature.

Curvature Prevalent.—In spinal curvature we have the beginning of a deformity so prevalent that *it exists in two out of every three women and in one out of every five men.* In most cases the curvature does not go beyond a certain point unless there is present at some time a debilitating disease. I have generally found that in the extreme cases the deformity only becomes rapidly severe in an ailment such as typhoid or influenza. The reason probably is that such diseases are followed by a general want of tone in all the tissues, and consequently any vicious habit of growth finds less resistance. One curious feature in nearly every case of lateral curvature is the want of mobility in the lower ribs. Of course the spiral nature of the curvature causes a cramping of the lower chest, which is, on the one hand pathological in itself, and on the other hand a most important matter to remember as regards the cure. Another feature universally present is the drooping forward of one or the other shoulder and the consequent protrusion of the shoulder blade. In various muscles in connection with the spine there is an almost unaccountable change in them, accompanying the progress of the curvature and finally exaggerating and hastening it. Some muscles on one side become stretched and flaccid, while the opposing muscles on the other side become short, thick and powerful.

Phenomena Encountered.—To sum up the phenomena which we have to contend against, they are:

First. Muscular irregularity or asymmetry in development.

Second. Bony changes.

Third. Reduction in the cubic capacity of the lower chest and want of mobility in the same region.

Causes of Curvature.—To sum up what may be regarded as the causes of curvature, we have:

First. The greater use of the right hand, causing over-development of the muscles extending between the spine and the shoulder on the right side. This is the muscular cause.

Second. Faulty position: (a) The writing or reading position, which gives the curve a spiral nature, and (b) the standing position—*i. e.,* supporting the weight of the body on one foot only, which produces the lateral curve.

The other changes of ligaments, bones and muscles are to be regarded as consequences and not as causes, but they are consequences which tend in their turn to gradually heighten the deformity.

Treatment for Curvature. — The treatment to severally convert these conditions is:

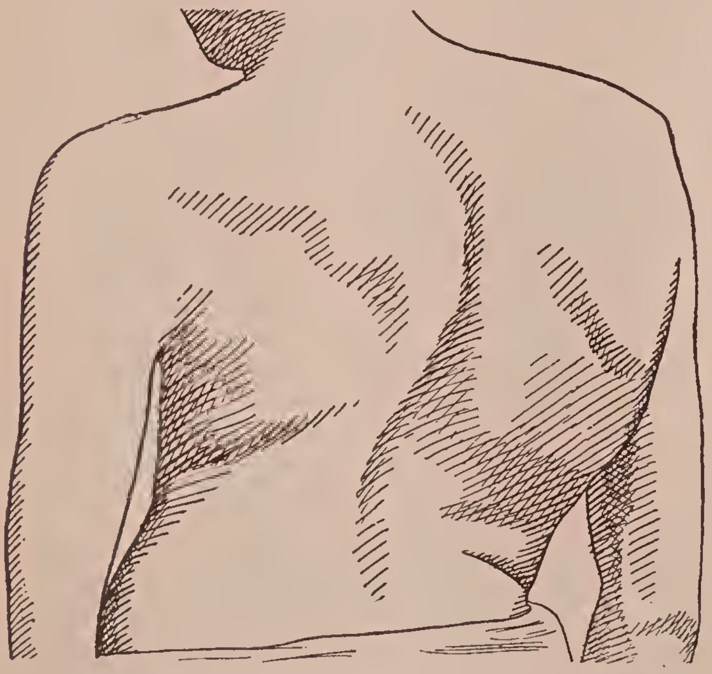
First. Special exercise to develop and strengthen the lax muscles.

Second. (a) Special exercise with the view to oppose osseous and ligamentous changes which have accompanied the curvature. (b) Proper habits of carriage in walking, sitting and standing, to the same end.

Third. Deep breathing exercises and exercise without breathing, to develop the lower chest and to remedy the pathological rigidity of the walls of the lower chest.

Fourth. General exercise, fresh air, cold spinal shower or douche.

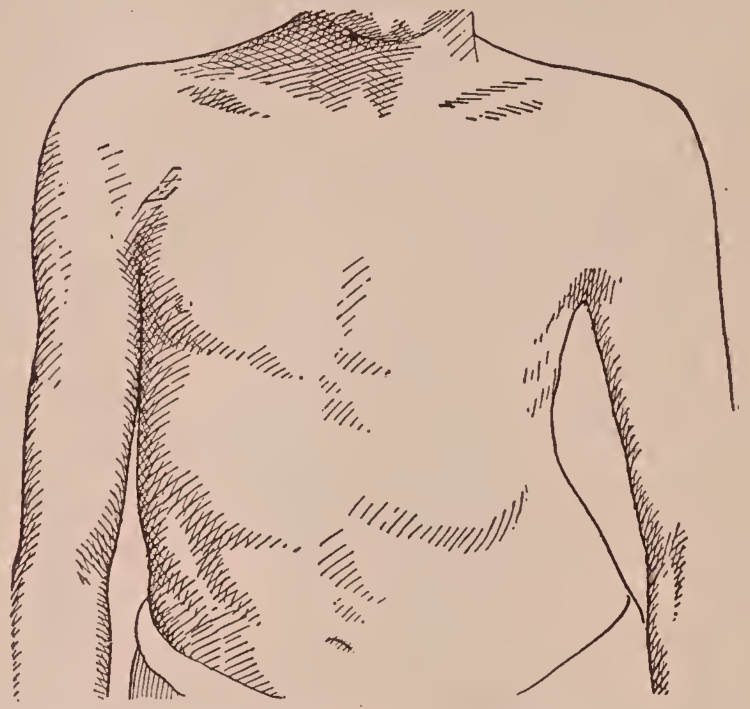
In the above will be found the beginning and end of rational treatment for lateral curvature. All apparatus, such as jackets, stretchers, backboards, etc., I am convinced, in most cases are not only useless, but are also harmful, since they produce a further muscular weakness and a further ligamentous weakness which permit the deformity to make still more rapid progress.



CASE 4. Lateral Curvature in a Girl.

Method of Curvature Diagnosis.—I have endeavored to find a way in which a medical practitioner can determine for himself the muscles which should be specially developed without always being compelled to have recourse to an expert. It may be done in this way: If you take Case 4, let the girl's right arm be extended straight out from the shoulder, and let her press down on your opposing hand. You will find that in this case the curvature is brought right by the action of the latissimus dorsi and one or two minor muscles. If, however, you get her to press upward against your hand, you will find the curvature greatly exaggerated. The obvious deduction is that special exercise must be given bringing in the downward movement of the right arm behind the back.

Again, in Case 4, let the hands be outstretched from the shoulders. Now, if the hips are kept rigid and the upper part of the body rotated from the waist, so as to bring the left arm forward and the right arm backward, it will be found that the curvature is brought straight. If you reverse, bringing the right arm forward and the left backward, the result will be an exaggeration of the curvature.



CASE 5. Lateral Curvature. (Front View.)

Correct Position Must be Maintained.—It must be pointed out that it is impossible to remove the curvature by exercise unless the patient gives up the evil habits acquired in standing and sitting. To take the question of standing, which is often, perhaps, the exciting cause of the curvature; no child who has no curvature should be allowed to assume the attitude of the "stand-at-ease" position, throwing the weight of the body on one foot, as was explained; but, however, when curvature exists, it will always be found that the patient is addicted to this habit always with reference to one foot. If you try to get him or her to throw the weight of the body upon the other foot you will be told that the position is uncomfortable and gives no rest. The ordinary vicious position, I repeat again, is standing with the right foot drawn back, knee straight, the left foot forward, knee bent, the weight of the body thrown on the right foot. If you watch the patient's back (uncovered) when this position is taken, you will find that the curvature is greatly exaggerated. If, now, you get him or her to stand with the left leg drawn back, left knee straight, right leg advanced, right knee bent, the weight of the body thrown on the left leg, the patient will find it uncomfortable and wish to change, but on looking at the back you will find the curvature greatly improved. Of course it is obvious that until the curvature is much better the patient should make it a practice to assume the "stand-at-ease" position with the weight thrown on the new foot, whichever it may happen to be. Indeed, I think that under these circumstances most of a man's work, if it be desk work, should be done at a desk where he can stand and dispose all the weight of the body upon the one foot as before described. Certainly the ordinary desk position ought not to be permitted: A great deal may be done in the way of prevention of lateral curvature by teachers, nurses or governesses seeing that children sit squarely to the table or desk, and stand with the feet on the same level, throwing the weight equally upon both.

Nature of Exercises Required. — The maintenance of the correct position, to counteract the new ligamentous and osseous formation, is extremely important, and should be practiced in front of the mirror. The patient should teach himself to walk as squarely as possible, and when standing to let the bodily weight rest equally upon both feet. It will be found that people with curvatures have an instinctive inclination, when walking in company with any one else, to walk on the one side of their companion only. In Case 4, for example, the girl would invariably walk on the right side of her companion. This habit must also be rectified. To counteract the ligamentous and bony formation the exercises prescribed should consist of side bending movements toward the convex side of the curve. In Case 4 such movement should be done toward the left. The deep breathing exercises to develop and render mobile the lower part of the chest are of the very greatest importance. We may take it on this principle: The natural shape of the chest with a straight spine gives the utmost cubic capacity within the smallest perimeter. Any distortion or nonformation cramps the cubic capacity. And, therefore, by bringing pressure to bear upon it within by chest development exercises, the tendency is to counteract the distortion. If you take, for example, an empty bladder or a half-empty bladder, you can twist it or distort it with ease; but if you blow it up, inflating it to the fullest extent, it must assume its normal spheroid shape.

The Body Must be Healthy.—Measures for improving the general health are of the utmost importance. It has been seen that it is only under conditions where the bodily strength is seriously weakened, and where the tissues lose their normal tone, that lateral curvature develops to any pronounced or alarming extent. Therefore one great element in the cure must be the improvement of the general health and tone of the tissues. This can be done, as has been suggested, by general exercises, fresh air, cold sprays or douches.

Constipation.

The Remedial Effects of Exercise.—Recently we have come to understand the remedial power of exercise and to utilize it as a strengthening and regenerating factor of the very highest value. In many cases, however, exercise not only acts as a preventive, but assists convalescence and actually plays a direct part in the cure of bodily affections, as has been indicated in many instances, such as congestion of the liver, nervous debility, fatty degeneration, muscular atrophy, rheumatic disorders and all diseases of the lungs. The principle of the cure does not lie in any vague or half-guessed application, but in simple and easily understood facts. The chief point in the value of exercise rests in the question of movement massage. This is a term which I have used several times, and which I now desire to explain. Speaking generally and non-technically, the direct method of affecting any part for the better rests on two things:

First. Increasing and quickening the circulation within that part.

Second. Improving the quality of the blood supplied to that part.

Movement Massage. — Movement massage secures the first by the compression and relaxation of the tissues affected. General exercise brings about the second by strengthening the heart, securing the thorough oxygenation of the blood and improving the digestion. It may be asked wherein this movement massage differs from ordinary massage. Ordinary massage is too partial, and at the same time is not altogether free from danger; especially where the internal organs are affected, the ordinary massage may cause dangerous inflammation. This is a result which movement massage never produces. To illustrate, we shall take the case of the lungs.

The Effect of Movement Massage on the Lungs.—The various breathing movements given expand the chest wall in such a way as to quicken the circulation of the blood within the lung; in addition to this, the waste products are more quickly removed, and at the same time the blood supplied is richer in quality. The result of such movements is an increase of lung tissue which would be almost incredible if it were not verified by the tape and spirometer. In the average individual the chest wall is shrunken and flat, the lung is collapsed, owing to the feeble circulation, and less than half of its tissue is actually used; but under the movement massage of breathing exercises the new conditions of development give extraordinary results. It is no uncommon thing to find an increase of two inches in the chest girth and fifty cubic inches in the capacity of the lungs brought about in a single month. All this is healthy—not unhealthy—tissue, and the lung capacity is that of healthy, active lung instead of dormant, unused and ill-developed lung.

Effect of Movement Massage on the Abdominal Organs.—This will serve to illustrate what I mean by movement massage. What I desire to direct your attention to particularly is the movement massage of the abdominal organs. From my previous remarks you are doubtless aware of the result of exercise upon the digestive organs. Here it is simply a question of the movement massage by which the gases of fermentation in the stomach and bowels are removed, the muscular walls strengthened and improved in tone, the circulation increased and the waste products more swiftly and effectively removed. In this way the healthy tone of the bowels is soon restored and the functions improved. Hence it is evident that movement massage is particularly applicable to constipation.

Prevalence of Constipation.—The plain fact is that half the people in this country are suffering more or less from constipation. Doctors forget it, the sufferers themselves forget it; but there is one class that does not, and that is the great army of pill manufacturers. These pills simply contain one or two drugs, with the one object of relieving constipation. But the fact is that the use of medicine in disorders of the bowels due to lack of exercise is uniformly bad, for it hastens the very weakness, by the after-results, which it is supposed to cure. *Exercise will remove it entirely by giving the intestine its proper tone.*

Constipation Poisoning.—Now, I want you to realize that constipation means the absorption into the system of poisons. The blood supplying the various tissues carries poison to every cell in the body. In passing through the brain it poisons the delicate nerve tissue and sets up the familiar headache. Passing through muscular tissue it poisons the muscle cells and produces the muscular languor and disinclination for muscular exercise. I imagine that this will be a new idea to many of my readers, to look upon constipation as poisoning, but that is the simple fact.

Effective Cure for Constipation. — As I have said before, its cure does not lie in the taking of drugs, but in exercise. Constipation means want of tone in the thin, continuous muscle that shields the wall of the intestine. The more habitual the constipation, the more this muscular wall is poisoned and the more aggravated the trouble. Drugs will temporarily relieve the condition, but no drug will give strength to the muscular wall of the intestine, so that the condition rapidly becomes chronic and may even pass into that most miserable, hopeless condition—paralysis of the bowels. The one cure lies in strengthening the muscular wall of the intestine by exercise and movement massage.

Method of Treatment.—The exercises should be taken on an empty stomach, and a glass of cold water should be drunk before commencing. If the pupil has the leisure and inclination, the same exercises may be practiced in the evening, except that a glass of warm water should be taken before commencing. After exercising the clothing should be resumed as soon as possible. A cold bath should invariably follow the exercise. The foods taken should be simple. In the case of women, tea, and in the case of men, spirits, should be used in the strictest moderation. All food should be thoroughly masticated and eaten slowly. No meal should be hurried over, and the sufferer will do well to remember the adage, "After dinner sit awhile." If these instructions are carefully followed out, the pupil will find that the health and vigor of which he has been deprived by fœcal poisoning will return to him; that the skin, instead of being discolored, will become fresh and pure, the eye bright and clear, and the brain strong and unclouded.

Obesity.

The Meridian of Life.—As a man slips into the thirties he usually finds the fight which he fought in his teens and twenties has put him more or less in a secure position. His life becomes smoother. The element of luxury gradually creeps in, the pleasures of the table are more keenly appreciated. The outdoor sports of his young days are left behind, and he develops the roundness of figure and the plumpness of face which at once bespeak the successful man. The meridian of life has come, and has come early, owing to civilization and its customs. The savage has a long youth, a brief middle age, and a long old age. Our friend has, as I have said, reached the meridian of life at the early age of thirty, and for thirty years more he will remain there. In other words, he will eat more than is good for him, he will take life easily, and he will not exercise. Consequently his ailments are mostly of the abdominal nature—gout, rheumatism, liver complaint, indigestion, constipation and obesity.

Obesity Defined. — I shall at this point only speak of obesity. Obesity is not only an accumulation of fatty tissue and a superabundance of that tissue, but it is a degeneration of tissue and consequently a disease. When the higher tissue, or nitrogenous tissue of muscle or organ, should be formed, only fatty tissue is formed. The fat not only invades organic or muscular tissue — it displaces it. Every one is familiar with the dangers of fatty heart, when so much of the muscular tissue is displaced by fat that the heart is unable to perform its function. In the same way we have fatty liver, fatty muscle, etc., although the general public is not so familiar with these diseases.

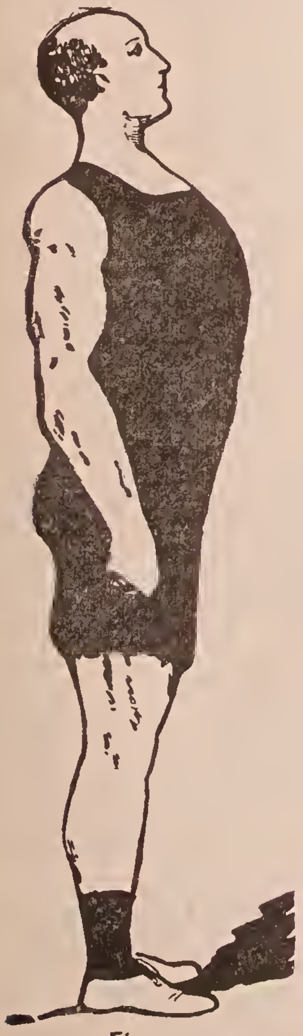


Fig. 1.

Exercise Cures Obesity. — Numerous treatments, diets and baths have been recommended for curing obesity, but exercise is the only treatment I have known to be uniformly successful. Unfortunately, it is the most distasteful of all treatments to the unfortunate sufferer, because his low vitality has made him lazy. Turkish baths will not effect the reduction of fatty tissue. They certainly set free a considerable quantity of the water held in fatty tissue, but that water will return as soon as any liquid is taken into the system. Now, the chemical heat which is engendered by muscular activity will burn up, so to speak, the fatty tissue—will actually destroy it altogether, as a tissue of low vitality ought to be destroyed. At the same time, the muscle underlying the fat will be made strong, which is absolutely necessary.

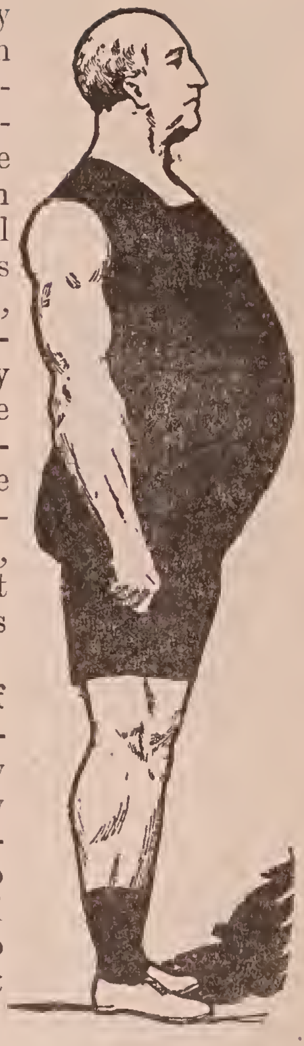


Fig. 2.

The Physical Causes of Obesity. — In the accompanying illustrations it is not only the actual quantity of fatty tissue which causes gross protrusion, but it is also due to the fact that the muscular wall of the abdomen has become so weak that it cannot support the weight, and consequently the mass becomes pendulous. Let us discuss the accompanying diagrams. Fig. 1 shows the man of middle age as he should be; Fig. 2, a man of middle age who has been an athlete in his youth, but who has given up exercise and fallen away. He is still a powerful and well-built man, but already the proper relation between chest and abdomen has disappeared. Fig. 3 represents a man of middle age who never exercised much, who indulges freely in the good things of life, and whose portly figure is not kept in position by muscular support or, indeed, any support other than the waistband of the trousers. It looks a very sad state of affairs even from the outside; but it is when you come to examine the state of affairs internally that the true extent of the mischief is realized.

The bony pelvis exists for the support of the abdominal organs. The proper state of affairs is shown in Fig. 4, where the whole weight of these organs rests upon the bone, the well-developed abdominal wall keeping everything in position. In Fig. 5 the abdominal wall has lost all strength or tone, with the result shown. The abdominal organs have become misplaced; they have fallen forward and lie upon the flaccid abdominal wall. This brings with it the suction action from the chest, for the diaphragm is, of course, pulled down by the weight of the abdominal organs, which are no longer securely supported by the bony pelvic basin. It is for this reason that the chest is flat in stout persons, and that the proper play of the lungs and heart is so harassed as to make a stout person habitually out of breath. Rupture, too, is particularly apt to occur in this condition of affairs.

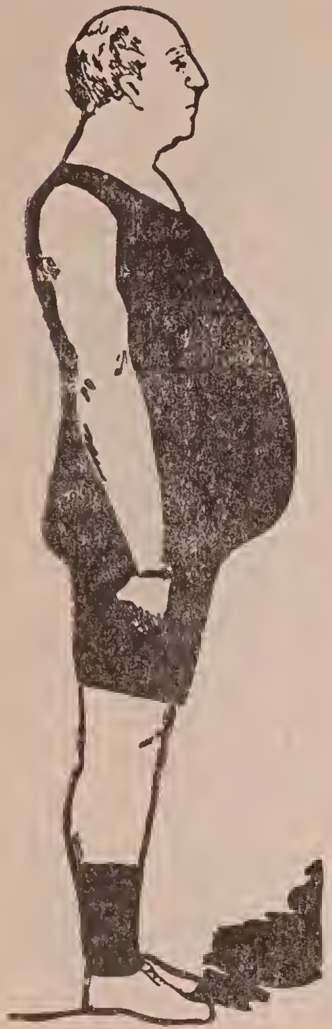


Fig. 3.

Steps in Obesity Treatment. — The first thing to do, therefore, is to practice and maintain a correct position and stand with the neck against the back of the collar, the chest braced up, and you will find the abdomen is drawn in. The sufferer in Fig. 5 would be quite unable to withdraw his stomach to the position shown in Fig. 4. He could manage it to some degree by the method explained, as shown in Fig. 1, by raising the chest and using the hands to assist in pulling the stomach back to its proper position. The next thing to be done is to strengthen the muscular wall so that it can draw back the fatty mass and maintain its proper position and at the same time burn away the fatty tissue as suggested. The exercise ought to be taken on an empty stomach, if possible, and in the morning. Heavy woolen should be worn, particularly over the fatty accumulations.

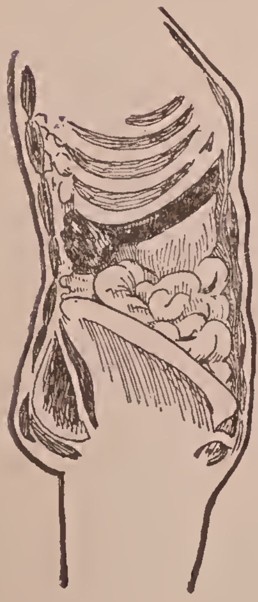


Fig. 4.

Obesity in Women. — It must be remembered that most of the blood returning from the abdominal organs to the heart passes through the portal vein and so through the liver, so that when we quicken the abdominal circulation through exercise, it can readily be understood what important physiological effects must follow. In women the accumulation of fat in the abdomen is greatly increased by the wearing of corsets, for the constriction of the waist due to the corset greatly increases the stagnation of the blood, and not only drives the fat downward, but also drives back and impedes the return of blood and lymph from the lower body; and it may be taken as an axiom that fat will increase where the circulation is most sluggish. For this reason corsets should be done away with.

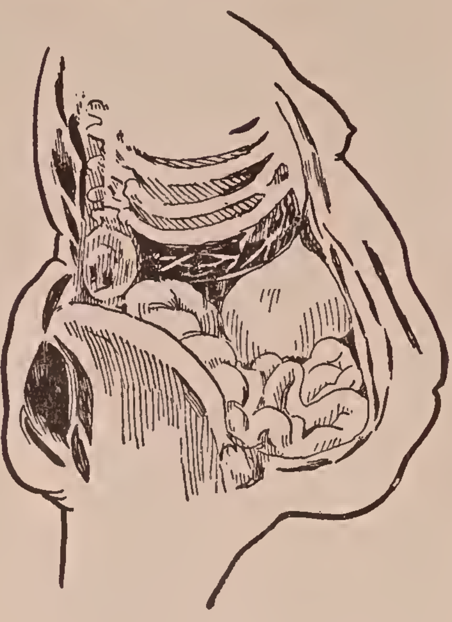


Fig. 5.

If proper exercises are practiced, it is possible in a very short time to reduce the unsightly protruding abdomen.

Sleeplessness and Indigestion.

Indigestion and Insomnia.—Predominant among the ailments brought about by the complex state of civilization are indigestion and its twin sister, insomnia. Then, again, those causes which are mostly responsible for indigestion also tend to prevent the sufferer from enjoying that refreshing sleep which restores the waste of tissue and nerve-power entailed by the workings of brain and muscle.

The Indices of Health.—Does a man eat and sleep well? If this can be answered in the affirmative, although he may suffer now and again from some trivial little ailment, it is safe to assume that he is in pretty good health. On the other hand, if he finds no pleasure in his food, goes to bed tired, and, after a miserable night, sinks into an hour or two of disturbed slumber, and arises still more tired, then he is out of health, and, as is commonly said, is "all run down," and is liable to become a prey to some of the serious maladies that affect mankind.

The Evils Which Produce Indigestion. — Of course every intelligent reader no doubt is aware of these facts, and every individual having ever so slight a knowledge of the physiology of the human body knows that appetite and sleep furnish the most valuable index to a man's health. There is a point in connection with indigestion which I am inclined to think is not sufficiently recognized—namely, that in order for the stomach to perform its work properly it is necessary that its walls be properly nurtured and developed. If you look at the average man who suffers from indigestion you will find that he is generally of the large-paunched variety, and that even if he has what is commonly called a "corporation," his stomach is flabby and almost totally bereft of muscle. In fact, with a great many people who have passed their early youth this portion of the anatomy is only kept in place by the clothing. We rail at women for tight lacing, and though I number myself among the most determined opponents of such a barbarous practice, at the same time I am willing to admit that it may be necessary to give the female figure some sort of support. But no such reason can be adduced in the case of a man. He ought to be able to stand erect and unashamed without feeling painfully conscious that out of his clothes he is simply an object for ridicule.

Cause of Abdominal Flabbiness. — This flabbiness to which I have referred I attribute to one cause. I believe it is due to a great extent to not having cultivated in early life a proper manner of holding one's self. Most people, if asked, can enunciate a perfectly correct theory as to the proper way in which to walk and stand. They will tell you that the shoulders should be pulled back, the chest thrown out and the stomach drawn in, and that in standing erect the weight should be thrown largely on the fore part of the feet. Nothing can be said against this, yet how many people practice it? If the habit of holding himself in the manner in which Nature obviously intended that a man should hold himself be cultivated in early life, it generally clings to a man, as witness the smart bearing and good carriage which the old soldier, though enfeebled by the weight of many years, still maintains almost up to the last. But my motto is, "It is never too late to mend," and the man of forty or fifty years whose protruding waistcoat is an offense and an insult to the midday sun, need not think that he is lost beyond a possibility of redemption.

A Simple Expedient.—Here I propose to give a piece of advice which, when contrasted with my previous remarks, may possibly lay me open to the charge of inconsistency. I am going to advocate a form of mechanical restraint. The man who wishes to acquire a correct way of holding himself, and to strengthen and keep in good condition the walls of the stomach, would do well to form the habit of having his trousers made slightly tight around the waist—not so tight, of course, as to compress the body and render breathing difficult, but just tight enough to be felt and to serve as a continual reminder not to allow the stomach to become a flabby and inert mass, only kept in position by the clothing. This, I should explain, I only intend as a temporary expedient, as I have just said, as a reminder of what is the correct position. Although the chest should be thrown out, I must caution those who follow this advice against falling into a common error and endeavoring to go about their daily vocations with their lungs inflated to their fullest extent. All breathing should, of course, be quite natural and easy, and the chest should be thrown out to a degree which is consistent with ease and comfort, anything like painful or strained effort being rigorously avoided. In time, of course, the correct position will be assumed unconsciously, and the man who has once secured it will find that it has become an absolute impossibility for him to walk along with his head down, his shoulders drooping forward, his chest hollow and his stomach thrown out. There are a great many people who think that it is a mistake for a man to walk along the street with a proud and dignified air. They say he is conceited and haughty. All such remarks originate from much the same reason as that which influenced the fox in the fable when he heaped abuse upon the grapes he could not reach. If you have a good chest and walk along the street with it thrown out, your shoulders pulled back, your back flat, and looking as if you find a good deal of happiness in the mere fact of being alive, you can safely disregard the cheap sneers of those who would have you believe that there is a great virtue in a miserable shambling gait.

Develop the Abdominal Muscles. — Those who are suffering from indigestion or insomnia will derive great benefit from assiduously practicing the contraction of the abdominal muscles. This will give firmness to the muscles of the stomach, and will materially aid in securing the correct position.

Causes of Insomnia.—Now we come to that malady which, if continued for any length of time, may, without exaggeration, be called one of the most terrible which afflicts mankind — namely, sleeplessness. It has been said already that inability to enjoy refreshing and unbroken sleep is one of the most unmistakable signs of ill health. It is necessary, however, to qualify this assertion; for, although the condition may be due to the body being generally out of condition, it does not follow of necessity that when the cause has been removed the ill effects at once vanish; on the contrary, it is not an uncommon occurrence for a man who is, comparatively speaking, in a good state of health, to be tormented by the fiend insomnia. Perhaps he has previously been out of sorts and has recovered from the particular ailments with which he has been suffering. There may be nothing specifically the matter with him. His appetite may have returned, and in the muscular sense he may feel strong and hearty. Were it not for the one thing, he would feel as fit as the proverbial fiddle; but he cannot sleep at night, or, if on going to bed he does fall to sleep, his rest is troubled and broken and he wakes up at short intervals. This is what we usually term insomnia.

Insomnia Further Defined.—Sleeplessness which arises from a specific and easily ascertainable cause is quite a different matter. That is to say, if a man has a bad toothache or has sustained some injury, it is obvious that it is the pain which keeps him awake, and in order to remove the sleeplessness it is necessary to alleviate the toothache. This is quite a different thing from the sleeplessness produced by an irritable condition of the nervous system, which works such havoc among men who use their brain exclusvely and who are usually of a high-strung temperament. How to remove this species of sleeplessness is a problem which very frequently taxes the ingenuity of some of our best medical men.

Insomnia is a Habit.—Now, I am of the opinion that the species of insomnia which has just been described is more or less a matter of habit. Doubtless some will scoff at this assertion, and yet if one considers it a moment I do not think the observation will appear quite so preposterous. Most people are agreed that sleep is a matter of habit; that is to say, that if a man gets into the habit of going to bed at a certain time and arising at a certain time, he ultimately forms the firm conviction that this is necessary for his bodily welfare. Now, if a man has been accustomed to regular hours in this respect, anything which prevents him getting his usual amount of sleep is apt to worry him and cause him to lie down at night with an uneasy feeling of uncertainty as to whether he is going to repose peacefully until the morning, or awake in an hour and lie awake listening to the striking of the neighboring bells.

The Habit a Disease.—As I have said, I believe that, in the first instance, sleeplessness is always caused by some disease (and beyond a certain point worry and anxiety are most emphatically diseases), and that if a man is suffering from insomnia for some time, although to all intents and purposes his body is perfectly healthy, the habit has become so fixed that the mere fact of consciously wishing to cure it produces the very state which it is his prime object to endeavor to avoid. How, then, can a man who is in this unhappy predicament escape from it?

Remedy for Insomnia.—I believe that this is mainly a question of will-power; that is to say, it will generally be found that a man who suffers from insomnia goes to bed with the natural intention of going to sleep, but has formed the habit of thinking about his business and domestic affairs for a little time after lying down. He only means to reflect for a little time, but one thought follows another, with the consequence that ultimately his brain is in an active condition and sleep is effectually banished. The great thing to secure sleep is either to be so physically tired as to render thought impossible, or else to resolutely close one's mind against the consideration of anything else but sleep itself. But it may be argued, in the case of a man of a nervous and worrying temperament, that the mere fact of determining that he will go to sleep will have just the opposite effect. That, I allow, is often so, provided the man's will-power were sufficiently strong, for then he could definitely center his thoughts upon one subject; but, unfortunately, with the majority of men will-power is comparatively weak, therefore other measures must be adopted.

Exercise for Insomnia.—Provided a man is not absolutely tired out, the best thing he can do is to go through some form of exercises immediately before retiring. If the exercises are to be taken properly, it is absolutely necessary that the mind should be centered upon the muscles and that everything else in the world should be forgotten for the time being. Apart from this, however, the effect of brisk exercise is to relieve the overloaded blood-vessels of the head and neck, and this in itself will predispose toward sleepiness. After the exercises a cold sponge-down should be taken just before getting into bed.

Cold Bath Conducive to Sleep. — In the case where a man is very much fatigued—as, for instance, after a very hard day's work—and feels utterly unable to summon up enough energy to go through the exercises, the cold sponge-down by itself will be found very effectual. Care should be taken in either case to thoroughly wet the forehead and the back of the neck; for if the remainder of the body be bathed and the head be neglected, the result may be a slight headache, which may defeat the object in view.

A Further Suggestion.—If, after taking exercise and the cold sponge-down, or the sponge-down alone, as the case may be, you find that you still lie uneasily awake meditating on the vanity of things in general, I have another suggestion to make, which I think will prove valuable, and that is to exercise in bed. Practice contracting the muscles as you lie in bed, putting all your will-power into each muscle in turn, and not confining your attentions to the muscles of the arms alone, but deal in turn with every muscle in the body. Herein will be found one of the benefits of having systematically cultivated muscle contraction such as I teach and insist upon. As an antidote for sleeplessness I have never, in the whole of my experience, found one which has proved so effectual as this, but it must not be done in a dilatory or desultory manner. The whole of the energy, physical and mental, must be, so to speak, projected into the particular muscle which is being contracted, and it stands to reason that when this is done there will be left no room in the brain for agitation over the events of the day or for worry as to what will be the outcome of the morrow.

Nature of Exercises. — It is not necessary for you to confine yourself to the exercises which have been described. For this reason the sufferer may practice any exercise which comes into his head, provided he does it with all his might and with all his will. For instance, he may try stretching out his whole body as far as possible. He may practice lifting his head off the pillow with the body kept quite still, the movement being done solely by the neck, turning his head from side to side, letting it revolve in a circular manner on the neck, keeping the lower half of the body quite still and raising a few inches from the waist by the abdominal muscles; or practicing the opposite movement, viz., keeping the upper half of the body flat, the legs stiff, and raising the feet a few inches, and, in fact, any of the numerous exercises which may suggest themselves that may be practiced without fear of injurious strain.

Just one more piece of advice. Perhaps you have suffered from insomnia more or less for some weeks. Do not think to cure it in a single night. It may take several nights, perhaps a week or two; but persevere, and I can promise you will not be disappointed. Of course I am taking it for granted that you are removing all predisposing causes. I do not profess to be able to work miracles. If you eat a big supper, the chances are that you will spend a wakeful night, exercise or no exercise; but it is not necessary for me to dilate upon this point, for I assume that the individual will not aggravate those causes which produce the disease.

How to Exercise.

In commencing my system of exercises there are certain questions which every student naturally asks. Probably the first of these questions is, "What part of the day ought I to devote to these exercises?"

When to Exercise.—The answer to this question must depend on the pupil himself—on his leisure and on his inclination. Some persons find the early morning the best and most convenient time; others prefer the afternoon, and still a third class find that they feel best and have the most leisure at night. I do not, therefore, lay down a hard and fast rule of time. The golden rule is to select such part of the day as suits you best, always avoiding exercise immediately after meals. If possible, let two hours elapse between a meal and exercise. Moreover, do not exercise just before going to bed if you find it has a tendency to keep you awake. Many of my pupils find that they sleep much better after exercise, but there are some upon whom it has a reverse effect.

How to Dress.—If possible, the pupil should always exercise stripped to the waist; if he wear a singlet it should be cut well away around the arms, so as to allow of free play for the muscles around the shoulder. It is also desirable to exercise before a looking-glass, for then the movements of the various muscles can be followed, and to see the muscles at work, and to mark their steady development, is itself a help and a pleasure.

Position in Exercising.—In performing the exercises the pupil should bend the knees slightly and keep the muscles of the thighs tense; the legs will thus share in the benefit of all the movements.

Progress by Degrees.—What I wish to impress on my delicate pupils is the desirability of progress by degrees. Many men before beginning my system of physical training have been so weak that doctors have thought little of the prospect of saving their lives, yet to-day they are among the strongest. They have progressed gradually, always careful not to undertake too much, and thus to adapt the exercises to their own individual requirements. It may be mentioned also that the old, as well as the young, may derive great benefits from my system, though all who are over the age of fifty should moderate the exercises. Pupils must not be discouraged because after the first few days' training they may feel stiff. It sometimes happens that a young man or woman, or perhaps a middle-aged one, sets out on the course of training with the greatest enthusiasm. After the first two or three days the enthusiasm, perhaps, wears off. Then comes a period of stiffness, and the pupil is inclined to think that he cannot be bothered to proceed with the course. To such pupils I would say, in all earnestness, "Don't be overcome by apparent difficulties; if you wish to succeed, go forward; never draw back." This stiffness, moreover, becomes a very pleasant feeling. You soon grow to like it; personally, indeed, it may be said that it is one of the most agreeable sensations I have ever had.

Time Required.—Frequently pupils ask me how long it should take them to get strong. The answer again depends on themselves, not only on their physical constitution, but also on the amount of will power they put into their exercises. As I have said already, it is the brain that develops the muscles. Brain will do as much as dumbbells, even more. For example, when you are sitting down reading, practice contracting your muscles. Do this every time you are sitting down leisurely, and by contracting them harder and harder each time, you will find that it will have the same effect as the use of dumbbells or any more vigorous form of exercise. It is very advisable for all pupils to get into the habit of constantly practicing this muscle-contraction. In itself it is an admirable exercise, but it is perhaps even more valuable owing to the fact that it improves the will power and helps to establish that connection between the brain and the muscles which is the basis of strength and "condition."

Method in Exercise.—It will be noticed that throughout my exercises I make a point of alternate movements. By this means one arm, or, as the case may be, one set of muscles, is given a momentary rest whilst the other is in motion, and thus freer circulation is gained than by performing the movements simultaneously and the strain upon the heart and lungs relieved.

Perspiration.—Another question which pupils are constantly asking me is whether it is right for them to perspire after the exercises. The answer to this question is that it depends on the constitution of the pupil. If you perspire, it does you good; if you do not it shows that your condition is sound already. Of course it will be understood that I am answering in this, as in other questions, for general cases. There are always exceptions.

Benefits Obtained.—Again, "What," it is asked, "are the general benefits of the Sandow system of physical training?" The benefits are not, of course, confined to the visible muscular development. The inner organs of the body also share them. The liver and kidneys are kept in good order, the heart and nerves are strengthened, the brain and energy are braced up. The body, in fact, like a child, wants to be educated, and only through a series of exercises can this education be given. By its aid the whole body is developed and, as will be seen, pupils who have conscientiously worked at my system testify to the good results obtained, not only in the direction of vastly increasing muscular strength, but of raising the standard of their vitality and general health.

Effect of Will Power.—For the beginner the most difficult part of my system is so fully to concentrate his mind on his muscles as to get them absolutely under control. It will be found, however, that this control comes by degrees. The brain sends a message to the muscles; the nerves receive it, and pass it on to them. With regard to the will power that is exerted it should be remembered that whilst the effect of lifting is to contract the muscles, the same effect is produced by merely contracting the muscles without lifting the weight. This question of "will power" has, I am aware, troubled a good many of my pupils. The majority find it difficult to "put all they know" into movements with small dumbbells, and consequently are apt to be disappointed at the results of their work. Not infrequently I have received a letter stating that the writer is doing the exercises an immense number of times, occupying several hours a day—three or four or even more—and yet does not find that there is very much improvement. The reason is obvious; he is simply "going through" the motions and not really working at them. On the other hand, here and there I come across a man possessing an amount of will power out of all proportion to his strength. The consequence is that he soon gets exhausted, and either cannot get through his exercises or only does so at the cost of becoming thoroughly done up and jaded. The great rule that progress in the direction of the exertion of will power should be gradual and ever continuing is one that many people confess they are unable to carry out.

The Magic Cold Bath.

Action of Cold Bath.—I am sometimes accused of being a bit of a faddist about the use of the cold bath, and possibly the heading of this chapter may give strength to that opinion. But its exhilarating and health-giving effects really justify the use of the adjective. The longer I live, and the greater my experience, the more am I convinced of its virtues. Let me advise every pupil after exercising, while the body is still hot, to take a cold bath. It does not matter how much he may be perspiring; the cold bath will prove exceedingly beneficial. He must be careful, however, not to take his bath if he is out of breath. The exercise will, no doubt, quicken the heart's action; but in from three to five minutes after the series is completed the heart should be beating normally again. For persons who suffer from weak heart I should not advise a cold bath. As a general rule there is no need to ask the question, "Is my heart weak?" For if it is weak you should know it beyond a doubt. After every little exertion, though the assertion may appear paradoxical, you will feel it beating in your head.

How to Take Cold Baths.—In advising cold baths I speak, of course, for persons in the enjoyment of ordinary health. The bath should be begun in the summer and continued every morning throughout the year. In the winter, if the room is cold, light the gas and close the window. If your hair is not injuriously affected by cold water—and in many cases, I believe, cold water will be found to strengthen it—begin, as you stand over the bath, by splashing the water five and twenty times over your head. In any case, if you are averse to wetting the hair, be careful to begin by sponging the temples and nape of the neck. Next, whilst still standing over the bath, splash the water fifteen times against the chest and ten times against the heart. Then jump into the bath, going right down under the water. In the summer you may remain in the water from ten to fifteen seconds, but in the winter let it be just a jump in and out again.

The Rub-Down.—The subsequent rub-down with towels is popularly supposed to produce half the benefits that result from a cold bath. I have no hesitation in saying that this is a great mistake. Let me explain the reason: As you get out of the bath you rub down first one part of the body and then the other, and thus, whilst one part is being warmed by the friction the other is getting cold. Many people who take cold baths in this way complain of touches of rheumatism, and the whole trouble arises, I believe, from different parts of the body being alternately warmed and chilled. In order to overcome the risk of this ill-effect my advice is this: Do not spend any time over rubbing yourself down. If you do not like the idea of getting into your clothes wet, just take the water off the body as quickly as you possibly can with a dry towel, jump into your clothes, and let Nature restore your circulation in her own way. You will get quite as warm by this method as by vigorously rubbing down, with the added advantage that the heat of the body will be more evenly distributed. If, owing to poor health or other exceptional causes, the circulation is not fully and promptly restored, walk briskly up and down the room. If you should still feel cold in any part of the body probably the bath is not suited to your constitution, and in that case it is not advised. In ninety-nine cases out of a hundred, however, the cold bath, taken as I have described, will have nothing but the most beneficial effects, and, if taken every morning throughout the year, it is the surest preventive that I know against catching cold. On the other hand, irregularity is liable to produce cold. In short, having once begun the cold bath, make a rule, summer and winter, never to leave it off. Personally I find the very best form of the cold bath is to get into your clothes after it without drying the body at all. For the first minute or two the sensation may not be perfectly agreeable, but afterward you feel better and warmer for adopting this method. The damp is carried away through the clothes and no particle of wet is left.

The Cold Sponge.—For pupils who have not the convenience of a bath-room a cold sponging down may be recommended as a substitute. In this case let two towels be taken and soaked with water. Rub the front of the body down with one, and the back with the other. This method prevents the towel from absorbing the heat from the body, and the cold sponging is thus distributed evenly over its surface. Afterward dry the body quickly as before, letting no time be lost in getting into your clothes.

Cold Bath Should Follow Exercise.—I have often been asked whether in the event of exercising at night it is advisable to take a cold bath afterward. My reply is "certainly." *Always* have a cold bath or sponge-down after exercising. It will make you feel "as fresh as paint," improve your appetite, and make the skin clean and firm, and be generally conducive to happiness and good health. Some people tell me that a cold bath immediately before retiring keeps them awake; if that be so, I should advise them to exercise earlier in the day. But the exercise and the cold bath ought to be regarded as inseparable.

Physical Culture for Children.

The First Lesson.—Physical Culture is applicable right through life, from its dawning day till its closing hours. The principle on which the human body is constructed is not that of adding a little, day by day, to the old bulk, but of destroying atoms, and then replacing them with new and additional ones. Nature teaches the babe in the cradle the rudiments of physical culture. Watch the chubby little fellow when he wakes. His fists are clenched and bored into his eyes; his tiny legs are drawn up and stretched out. "He is rubbing the sleep out of his eyes," says the fond mother; but the fact is that he is taking his first lesson in muscular development in response to a natural impulse.

Physical Culture as a Preventive.—In his crawling days, if left alone and not encumbered with outrageous clothing, the youngster continues to develop, and does it naturally and mechanically. It is when he gets a little older that the danger of physical neglect is greatest. It is one of the highest duties of the parent to see that their children begin to build the foundation of a sound body and healthy mind early in life. It will save them countless pitfalls, and make for their physical, mental and moral well-being. It stands to reason that if a boy or a girl is allowed to contract round shoulders through habitually stooping, or an ungainly walk through habitually slouching along, they will be heavily handicapped if they desire to take up physical culture in later life. Prevention is always better than cure, and I have carefully worked out exercises which may be begun when the child is, say, five or six years old, and followed until he is well on in his teens.

Advice to Parents.—Parents who desire to see their little ones grow into well-developed men and women may be advised to buy their babies light wooden dumbbells as playthings. Of course exercises should not be attempted until the child has reached the age of six or seven, and then considerable discretion must be used in prescribing the same. The general principle will hold true, that no general course of exercises can be laid down which will fit every child. The exercises must be mapped out in accordance with the physical condition and general health of the child. In some cases a boy or girl of ten years may be so delicate as to have no more strength than a more sturdy child two or three years younger, so that the exercises, in point of order, rotation and number of times to be performed, must be regulated accordingly. Those who have charge of children should not allow them to over-exert themselves, and, above all, to exercise violently.

Methods.—In the movements prescribed do not let each arm (nor both arms) move more than once in a second. Thus, for example, a simple exercise, such as for the biceps and triceps, would be twenty seconds. As a general rule, this time will be found sufficient to give just the exercise that is needed. Faster movements are not recommended for either young or old. See that children do not perform the movements with a jerk and that each exercise is performed easily and gracefully. When contracting the muscle take special care that they do not hold the breath Even adults should note this, for many pupils are inclined to do this unconsciously when bringing their minds to bear upon the muscles, but it is quite wrong, and the tendency must be striven against until it is overcome.

My Success With Children.—With children I have been particularly successful, by paying special attention to the development of the lungs. The development of the lungs in children is practically the only safeguard against pulmonary diseases, and mothers should make sure that these organs in their children are correctly developed, thus reducing the possibilities of consumption and other lung diseases to a minimum. The prevalence of post-nasal growths is remarkable in these days; but let me say that these growths in children can be prevented by proper attention to nasal breathing. I have devised a special series of light and simple exercises for this purpose that have proved conspicuously successful in a number of cases where the surgeon's knife has failed to remove these growths.

Physical Culture for the Middle-Aged.

A False Notion.—It is scarcely necessary for me to say that the benefits to be obtained by conscientiously working upon my system are by no means confined to the young and vigorous. On the contrary, it is particularly suitable for the middle-aged, who are all too apt to suffer from the effects of the period of physical indolence which has succeeded their youthful activity. To such, the system should prove invaluable. It is quite a false notion to suppose that when once youth is passed exercise is no longer necessary. *So long as life lasts, if an individual wants to keep healthy, exercise is just as necessary as food.* It is through neglecting to recognize this that so many men become aged before their time.

Effects of Sedentary Life.—When a man begins to get into middle life he has a natural tendency to "take things easy." He lives more luxuriously, devotes more time to the pleasures of the table, and exerts himself as little as possible. Is it anything to wonder at that his health suffers, that he grows fat and flabby, and that his digestive apparatus quickly gets out of gear? If in his youth he has been an athlete, the more will his changed mode of life tell upon him; it is, indeed, better never to have exercised at all than to exercise for a few years and then drop it entirely. It is for this reason we hear of the health of so many athletes failing them at a comparatively early age. And this failure is, as a rule, erroneously ascribed to the effects upon their constitution of their early efforts. Once and again errors in "training" may be responsible for poor health in middle-age, but in ninety-nine cases out of a hundred the complete cessation from active bodily work, combined with the greater indulgence which naturally follows, is alone responsible.

Exercise in Moderation.—Of course, while it is advisable that the middle-aged man should exercise regularly, I must warn him not to do too much. He must remember that what is perfectly safe and prudent at five-and-twenty ,may be rash and hazardous at fifty; in short, that he, while exercising consistently and steadily, must be careful not to overtax his powers. If he bears this in mind he will find that the discomforts and ailments which he has perhaps come to regard as natural to his time of life are quickly banished, and that, in spite of his gray beard and thinning hair, it is still "good to be alive."

Physical Culture for Women—A Talk to Women.

The Gifts of Health and Strength.—I have often thought that if advocates for Woman's Suffrage would spend their time in urging women to take advantage of the certain physical privileges that lie at their feet, instead of agitating for political rights, that may or may not prove to be privileges when they are obtained, they would do much more for their sisters of to-day, and vastly more for those of generations to come. It ought not to be difficult to persuade a woman that inestimable treasures—the gifts of health and strength, of elasticity of body and freshness of mind—have only to be stooped for and picked up. And yet the task is not as easy as it seems, and the stumbling-blocks are Fashion and Custom. Women, more than men, are guilty of neglect of physical culture, though even with men it is often necessity rather than virtue that is responsible for the saner treatment of their bodies.

The Woman of To-day.—The nature of Men's work compels them to dress rationally, and brings their muscles into play, so that they are obliged to keep up to a certain standard—not a very high one, it is true—of bodily development. But, unfortunately, it cannot be denied that within recent years the physique of women has been on the down-grade. What we call our higher civilization has brought with it artificial conditions of life that are responsible for this physical decline, and the irony of it is that it is not a necessary adjunct of civilization. There is absolutely no reason why the broader life, the higher education, the deeper sympathies—the wider outlook, in a word—of the twentieth century woman should be attended by a weaker body, a less shapely figure, and a less robust constitution. Nevertheless, it must be admitted that such is the case. The women of fair France—that land of sunshine and pleasure—form a most striking example of the physical retrogression consequent upon a slavery to fashion. The French race is slowly but surely losing its place among the civilized nations as regards physique and even actual numbers, and the reason is the systematic sacrifice of bodily health and beauty upon the altar of fashion. There is a great danger that American women are following in the footsteps of their sisters across the water.

Effect of Modern Inventions.—It is interesting to glance back through the generations, even as far as the ancients. If we stop midway back we find that we drive where our ancestors walked; we are replacing the stairs with the elevator; the automobile is displacing the bicycle; we favor indoor amusements rather than outdoor games and contests. In short, we are in danger of becoming a race of people whose sole physical exertion will consist in pressing buttons and turning levers.

The Ideal in Woman.—It is not difficult to understand how the ideas of womanly beauty came to demand that the figure should be twisted and contorted. Rodin, far and away the greatest living sculptor, gives it as his dictum that an artist's tendency ought to be toward the accentuation of

Nature's lines. That is to say, the tendency ought to be toward making the full parts fuller, the slender parts more slender, the broad parts broader, and the small parts smaller. And in this I consider he is right. Doubtless the same idea, unexpressed, is at the bottom of the cramping corset and the pinched foot. It is forgotten that there is an ideal which must be observed, and which cannot be passed, and it must be remembered that the ideal must be attained by development, not by contortion.

The Demands of Fashion.—It passes the wit of man to discover how self-respecting women can employ the various deceptions so commonly used, with a view to heighten their attraction. We have the high-heeled shoe, the pointed toe, and many other artifices which will occur to the minds of my lady readers. Now, this is all bad. It is foolish, to begin with, for the creation of woman was not so imperfect that it requires the art of man to improve upon it. Such contrivances in men would be properly despised, and in women they often are. But few women can escape from the thralldom of fashion. What high personage it is, or secret conclave of great power seated on some mysterious dictatorial throne, I know not; but, once the edict has gone forth, no tyranny, no imperial Cæsar, was ever obeyed with such absolute and slavish obedience. The word goes forth that the skirt is to trail along the ground. No one knows where the word comes from; but from country to country, and continent to continent, it goes, and the world of women wears the trailing skirt. I regard this compulsion to obey fashion as the great cause of the physical decline of women. Whatever the cause is, the results are serious.

Evils of Fashionable Dress.—Women, I take it, were meant to be healthy. A woman was not meant to go through life a tremulous mass of disease and weakness. But, in spite of this, the modern mother teaches her growing girls as though this were one of the first laws of Nature. Now, let it be understood, to begin with, that any arrangement of dress that does not give free play to the body is bad. The narrow, thin shoe, for example, not only destroys the foot and makes it ugly, but interferes with the circulation, causing chilblains, etc. Not only does it interfere with the local circulation, it also does with the general circulation. I have seen women faint from wearing too small shoes, and half the colds and chills are brought about by the feet being insufficiently protected against the cold. It is hardly necessary for me to say anything here about the corset; my views on this subject are well known.

A View on Change in Dress.—The changes which I should like to see in the life of the modern woman are three: (1) Loose, easy clothing; (2) encouragement to engage in outdoor sports in girlhood; (3) systematic exercise, carried on throughout life. As regards clothing, the corset should be so mobile as to give the muscles of the trunk free room for play. Of course, the ideal figure is one in which the muscles are so developed that they will need no support, and yet allow the figure to be graceful. The Venus de Milo is for us the absolute type of feminine beauty. If any curious reader takes the trouble to secure a picture of Venus de Milo, and sketch in a "corset-waist" over the figure, she will find how little it improves the statue. But that pitch of perfection is not for our day. Generations of destruction must be followed by years of construction, and I do not think it at all likely, or indeed advisable, that women should leave off corsets at once. What I do advise, however, is the use of common sense in the choice of the corset. The dressmaker's law is that the woman is made to fit the corset. Reverse this law, and make the corset fit the woman. Then as the muscles grow they must be allowed room to contract and expand, and not be put in splints.

Evils of the Corset.—Just think, for a moment, of the results of corset-wearing; lateral curvature of the spine, short-windedness, susceptibility of lung disease, anæmia, congestion of the abdominal organs, are some of them. Now, I want women to understand that they can be healthy; and with health comes beauty. But neither can be obtained by the aid of the dressmaker.

Evils of Tight Shoes.—But the corset is not the only article of wear that harms the body. Take the average woman's foot-gear, and you will find that it is an instrument of malformation—an implement of torture as surely as the infamous "boot" of the Inquisition, and borne with equal heroism in a less worthy cause. The two simple illustrations given here explain themselves.

Exercise is Demanded.—It would be absurd, however, to attribute all the ills to which woman's flesh is heir, to corsets and shoes. Negative evils as well as positive evils are responsible. There has been dire neglect, as well as foolish distortion, and whilst the adoption of common-sense clothing is a step in the right direction, exercise is the one thing that will first bring all the muscles into a healthy condition, and, second, make them of true value to their possessor. Now, it was exercise, simple life, and untrammeled bodies that made the Grecian women what they were, and it is exercise, simple lives, and untrammeled bodies that will make our modern women modern Venuses.

"What exercise?" you say.

First. Simple exercise on the hill-side; unconscious, recreative exercise.

When Sydenham, the father of English medicine, was dying, he said that he died happy because he left behind him two great physicians—fresh air and exercise. Nothing could be truer; and I am happy to say that these two essentials to health and strength are not denied to women to-day as they were one hundred years ago.

Second. Systematic exercise.

"But," you will say, "the Greek women never exercised systematically."

The Greek Woman.—Yes, that they did, and in public too, day by day, in Athens and Sparta. In Sparta, both male and female had to exercise publicly in the parade ground from the age of five. What exercises they did we know not, nor shall we ever find out, I am afraid. Their system of movements, which must have been an ideal one to produce such ideal results, is irrevocably lost, but I do not despair of replacing it. Science has taught us much which the Greeks did not know, and with a combination of science and experience much may be done.

Effect of Exercise.—What is the effect of exercise? one may ask. The first, but, in my opinion, by no means the most important result, is the increase in physical strength. And yet this means that the woman is capable of standing a greater or a longer strain than before; that tasks which before were exhausting are now performed with ease, or even become exhilarating. It is by no means the muscles of the limbs that stand alone in need of development. It is the muscles of the trunk. To overestimate the importance of these muscles would be impossible. The great muscles of the torso are the muscles which usually give way under a strain, and strength in the limbs is of but little use unless there be present also strength of the great trunk muscles. And when we can secure a system of exercise which does not omit a single part of the organic and muscular system, then we may rest assured that the practice of it will give a complete balance of health and vigor in every part that will make the individual's life an enviable one.

Exercise makes every tissue healthy by strengthening the heart and circulation, deepens the lungs so that the blood is properly oxygenated, assists the venous circulation by movement and muscular contraction so that the portal vein is properly emptied and the liver circulation is not allowed to become sluggish. The improved digestion which follows, as a matter of course, together with the other changes, gives a health and purity of skin, a cleanness and firmness of tissue, symmetrical proportions, bright eye, and clear brain, without which the beauty, vigor, and happiness of health can never be attained.

Out-of-Door Sports.—The ordinary out-of-door sports are excellent, although they are not so good as the ancient Greek game of ball; but exercise, to be of proper avail, must be systematic, to secure an even development and symmetrical proportion of all parts.

Fencing.—Fencing has come more into vogue in late years, but it is almost certain to cause curvature of the spine in a girl whose spinal muscles have never been permitted to become strong, but have been kept weak by the support of artificial stays. Even in strong men "fencer's scoliosis" is extremely common. Rowing and cycling tend to contract the chest, and dancing in a close room, with intervals of ices and sitting out, can hardly be classed among the exercises.

Exercise Will Not Make Women Muscular.—We must, therefore, fall back upon a system of exercise specially constructed so as not to omit the development of any single part or organ. And let it be remembered that the great objection to women exercising—namely, the fear of becoming muscular—is quite without foundation.

I am quite aware that there is a very widespread notion that exercise tends to coarsen and render a woman unbeautiful, but that is absolutely false. Were there any truth in it I should indeed despair of converting my fair readers to my way of thinking, for truly it is woman's mission to look beautiful. But the idea is absurd; Nature, which intended woman to look lovely, also intended her to be healthy: indeed, the two are practically synonymous. Of course, improper, violent and one-sided exercise will naturally result in making a woman clumsy, heavy, and ungraceful, but proper exercise, having for its object symmetrical and perfect development, will have an exactly contrary effect. Curiously enough, the visible effect of proper exercise upon a woman's muscles is not precisely the same as upon those of a man. Regular and gradual progressive exercise will not make a woman's muscles prominent, but will cause them to grow firm and round and impart to the outline of the figure those graceful contours which are so universally admired. Without well-conditioned muscle the most beautifully-proportioned woman in the world will look comparatively shapeless and flabby; her muscles are not required to show up as in the case of a man's, but they must be there all the time as a solid foundation for the over-lying flesh. Take a woman's arm, for instance, if it has been duly exercised and developed it is easy enough to see that its shapeliness and good modeling are due to the muscles; white and soft though the skin may be, you can tell at a glance that it is firm and elastic to the touch. On the other hand, the arm of the woman who has never exercised the muscles betrays the fact unmistakably; it may be plump and round, but its lines are lacking in beauty, its movements in grace; and so with the figure generally.

Effects of Systematic Exercise on Women.—It cannot be too often repeated that woman is not simply a weaker man; she is physically an entirely different being. The muscles in women are long, and never develop in size so as to form large masses or hard, abrupt lines. In men the muscles are short, and, when they are powerful, one sees all over the frame the strong, striking lines and muscular masses characteristic of men of vigor. In women the muscles simply become firm, close-knit, and well-rounded, and show under the layer of fatty tissue intervening between muscle and skin only in soft, hardly discernible masses, just sufficiently to give a delicate moulding to the form. This layer of fatty or adipose tissue is peculiar to women; it exists in the male until adolescence, and then disappears; but in women it persists, except in disease or bad health, until the age of fifty. It softens all the outlines, so that the danger really is, not that woman should have too strong lines, but that want of exercise should cause her to have no lines at all, but a sort of shapeless rotundity. As this layer of adipose tissue does not form where no muscle lies between bone and skin, there is in woman where the bones are subcutaneous an exquisite dimpling, which is a characteristic beauty of the sex. In man, the bones in these situations show as hard, prominent masses. So it will be seen that in these and many other points women cannot approach to the masculine type, even if they try.

The effects of my system are very rapidly noticeable. It reduces the size of the waist, makes the limbs round, the figure pliant, the walk and carriage graceful and easy. For those women who are doomed to a more or less sedentary life it works wonders, and those whose means and occupation permit of their indulging in a healthier outdoor life will find it a splendid preparation for their favorite pastimes.

Just a word with regard to complexion. A fine skin and a good healthy color are the best proofs of the possession of good health. Indeed, without health a good skin and complexion are out of the question; and where is the woman who does not desire to possess both? She is indeed rare. Therefore, to those women who, while they do not set a high enough value upon health and strength for their own sakes, yet desire to be fair to look upon, I say the two things must inevitably go hand in hand. Whether your prime object be to obtain beauty or health does not matter; by working upon my system you will obtain both.

The Introduction of My System.—Until my system was published there was, if we except the Greeks, practically no such thing as the physical education of women. In England and America calisthenics, as they were called, consisted chiefly of exercises, or rather movements with light wands, which were practiced more for spectacular effect than for physically beneficial results, and were given to young ladies in high-class boarding schools, and described in prospectuses as physical education and deportment. These might be graceful when performed in concert, but would have absolutely no effect upon the physical well-being of the body, as in most cases the pupils were encouraged to be lackadaisical rather than to exert any physical energy. The style of deportment that was prevalent only a few years ago was responsible, to a large degree for certain common malformations.

Why My System Benefits Women.

I am exceedingly anxious to remove the impression, which has, I fear, gained ground, that my system is not a thing for women. Now-a-days, when women have practically freed themselves from the antiquated ideas of a generation or so ago, there ought to be small difficulty in convincing them that to make the best of themselves, in a physical sense, is just as imperative a duty for them as for their brothers. Women go in for all sorts of sports and pastimes to-day; they bicycle, row, play tennis and hockey, and not infrequently display no small degree of excellence in sports which have hitherto been regarded as "for men only." This is a hopeful sign, but I am not at all sure that in many cases it is not more provocative of harm than good. Women are possessed of a great amount of nervous energy, and, unless their bodies and organs are gradually and systematically trained to bear exertion and fatigue, they are likely to attempt performances which are quite beyond their physical power, although, buoyed up as they are by a fund of nervous energy and mental exhilaration, they may observe no ill-effects at the time. This is one reason why it is so advisable for women to commence by working upon my system, which is so mild and gradual that they can pursue it without any risks, and, while daily growing stronger and healthier, be scarcely conscious that they are making any effort whatever.

Married Women and Physical Culture.—Married ladies are frequently writing to me, testifying as to the value of my system of Physical Culture, which, as they say, has made them such healthy mothers, and signifying their intention of bringing up their children on the principles laid down by me for the cultivation of sound health and strength, since these were the means of rescuing them from an unhealthy and weakly existence. This is a point on which too much emphasis cannot be laid, and women should remember that in properly developing the trunk muscles they are not only saving themselves untold agony, but are really building for the generations to come.

My System.—I have devised a regular set of exercises, arranged on scientific principles, and in them I have taken into consideration the harm already done, and have given the weakened parts special attention. These exercises ought to be gone through before a meal, not after, and should invariably be followed by a cold sponge, cold chest sponge, tepid sponge, warm bath, or cold bath, according to strength. The spinal spray or spinal douche is also good. If, after the bath, a splendid glow is not felt, then you are not getting the full benefit, and you must modify it, making it tepid, instead of cold, for example, or limiting it to the chest instead of making it general.

A Word on the Bath.—No unnecessary time should be spent in the bath, and the clothes should be resumed as soon as possible. It is a mistake to stand about the bathroom elaborately drying the body, on account of the risk of cold. While one part of the body is being vigorously scrubbed to induce warmth and dryness, another part may catch cold. My advice is that the body should be wiped rather than rubbed, and as soon as the superfluous water is removed the clothes should be put on while the body is still damp. There is less danger of cold being taken if this course is followed than if great pains be taken to dry the body before putting on the clothes.

How and When to Exercise.—The exercise should last about twenty minutes, though it is advisable to work up to that. At first it should be gone through gently, and in a day or two the movements may be performed more thoroughly and with more will power. If exercise is taken at night instead of in the morning, it should be followed by the bath or a sponge down. If the bath before retiring causes sleeplessness, take your exercise earlier, but do not give up the cold bath; it is one of the surest known preventives against catching cold. It will be instructive, while dressing after the exercise and bath, to stand with back to the wall, heels, hips, shoulders and back of head touching the wall. Now attempt to button the corset as you wore it before. You cannot. Well, you are beginning to see the difference between being your dressmaker's woman and Nature's woman.

Effects of Non-Exercise.—If a woman persistently neglects to exercise those muscles which Nature has provided her to assist her in the great crises of life, she will have to pay the price—a double price of pain to herself and risk to her offspring. Civilization has rendered maternity a painful, dangerous and tedious business. The women of the olden days were saved much suffering and danger. The Roman and Grecian women did not wear corsets, but they accompanied their husbands to the wars, and when a child was born they took it up and walked on. We find savage women doing the same thing now; but in highly "civilized" countries a child is born only after exhaustive exertions, and the mother is often ill for weeks, and her whole nervous system is shattered.

Muscle-Bound.

Ideas Prevalent.—I am questioned so frequently about the condition known as "muscle-bound" that I want to drop the thread of my talk for a moment to explain its true meaning. Probably ninety-nine out of every hundred men would be unable to define the term. Most people rightly have the idea that when you speak of an individual being "muscle-bound" you mean that he labors under the disadvantage of not being able to use his muscles quickly, and then only uses them with great effort. The frequent coexistence of great muscular strength with this condition has led people to the curious error of imagining that the two are practically synonymous. While the two are often coexistent, it does not follow that one is the cause and the other the effect; that it to say, that great development of muscle causes a man to be "muscle-bound."

The Condition Defined.—In a few words I hope to make clear the exact meaning of this expression. We shall first consider a brief description of the general plan of the muscles and the manner in which they work. All the muscles of the human body (I refer to voluntary muscles) are arranged in pairs. For example, the muscles of the upper arm consist of the biceps and triceps; the former, situated on the inside, is used in flexing the arm at the elbow, while the latter straightens it out again.

Philosophy of Muscular Action.—Now, it is essential for rapid and easy movement of the limbs that these opposing muscles should be equally developed, for what is the result if one of any pair is developed to the neglect of the other? Let us take the arm as a familiar illustration. We will suppose that the biceps are largely developed and the triceps almost non-existent. As the biceps grow bigger and stronger, their natural tendency is to pull the arm up unless they are counteracted by the tendency of the triceps to stretch it out. In the case where the biceps are infinitely stronger than the triceps, their pulling-up tendency is but feebly resisted, and as a result they are perpetually in a state of semi-contraction. Now, when a muscle is contracted it becomes shorter. So the biceps become shorter and, owing to the want of power in the triceps, are never properly stretched out. Consequently they remain more or less contracted permanently; the tendons which secure them also shorten, and if the condition is not speedily remedied it becomes permanent. This is what we call being "muscle-bound."

Cause of Condition.—The reader will now have little difficulty in understanding how it is that men with great muscular development frequently suffer from this defect. It, of course, is due to uneven development. However large a man's biceps might be, were his triceps equally developed he would run no danger of being "muscle-bound." So with any of the other groups of muscles. Thus when it is thoroughly grasped what is meant by the term "muscle-bound," it is comparatively easy to see what gives rise to the condition. It is practically always caused by exercises which affect only a few muscles. This condition usually arises in the case of the biceps, since they are used more often than the triceps. This state is aggravated by the fact that, through ignorance or deliberation, much more attention is given the biceps than the triceps. Gymnasts are great sinners in this respect, and it is among them that cases of "muscle-bound" are most frequent. While it is quite possible in a gymnasium to adjust exercises so that every muscle is equally developed, it is seldom done.

Remedy Against the Condition.—To guard against this condition every muscle in the body must be equally exercised. Athletic sports or games will not ameliorate this condition, for I have studied the subject deeply and know of no single game or sport which exercises all the muscles of the body; most, indeed, only touch one or two groups. The only safe preventive lies in systematic scientific exercise.

Cure for the Condition.—Can this condition be cured? Yes! but the older the case, the more painful the cure. The process of repeatedly forcing the muscles to stretch, against their own inclination, until they can be completely relaxed, is lengthy and painful. It must be remembered that where muscle has been long neglected it seems to be incapable of acting upon any influence communicated from the brain. Before the proper connection between brain and muscle can be restored very great concentration is necessary. In very bad cases any attempt at cure must be gradual, otherwise the tendons may be strained or actually ruptured.

Characteristics of this Condition.—It is very easy to discover this condition. In fact it can be told by touch alone, without even an inspection of the suspected muscle. The "bound" muscle will invariably be found to be hard when in a state of repose—possibly nearly as hard as when it is consciously flexed; for as has been seen, it is practically always in a state of semi-contraction. It is quite a mistaken notion that the test of good muscles lies in their hardness. It lies neither in their quantity nor their hardness. *Quality* of muscle is what must be looked for, and the test of quality is the power of mobility of the muscle. A muscle to be in good condition should, when relaxed, be quite soft; when contracted, the harder the better. The greater the difference between the two states the better the muscle.

The Sandow System and "Muscle-Bound."—A reproach hurled at my system by those who have only a faint idea of what the system really is has been that it tends to make one "muscle-bound." I think I have demonstrated the inherent absurdity of such a suggestion. The persistent exercise of every muscle in the body renders such a condition absolutely impossible; however much the muscles are developed, they are symmetrically developed. These are points which I absolutely insist upon in my system. Many in a "muscle-bound" condition have taken up my system, and I am glad to say have met with the happiest results.

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ADDENDA

Consult the Addenda matter following page 620 for important occurrences to date.

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After the age of three continuous play begins to weary, and if simple instruction be not given mischief will more surely occupy the little mind and beget habits of disobedience.

"A CHILD IS BETTER UNBORN THAN UNTAUGHT"

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LEARNING TO SPELL

The words to be spelled are those which young persons first use, and therefore need most to spell correctly. They are so arranged in classes as to give an idea of their meanings, even if some of them should happen to be new to the speller. The plan is that of Prof. L. B. Monroe, Boston University.

GENERAL HOME WORDS.

door
en′try
floor
house
porch
room
stairs
clos′et
cup′board
di′ning-room
kitch′en
pan′try
par′lor
sink
at′tic
bal′cony
bed′room
cel′lar
cham′ber
gar′ret
li′bra-ry

KITCHEN THINGS.

ba′sin
broom
brush
soap
stove
tongs
fau′cet (fos′et)
grid′dle
ket′tle
sauce′pan
skil′let
tow′el
and′i-ron
bas′ket
dust′pan
flat′i-ron
grid′i-ron
ta′ble

DINING-ROOM WORDS.

bowl
cup
fork
glass
knife
spoon
la′dle
nap′kin
pitch′er
plate
sau′cer (saw-ser)
sil′ver
cas′ter
cru′et
plat′ter
side′board
tum′bler
tu-reen′

PARLOR THINGS.

chair
frame
grate
screen
so′fa
stool
car′pet
cur′tain
lounge
mir-ror
tas′sel
vase
brack′et
has′sock
ot′to-man
paint′ing
pic′ture
por′trait

IN THE BED-ROOM.

bed
lamp
quilt
pil′low
sheet
trunk
bed′stead
blank′et
bol′ster
cra′dle
mat′tress
tick′ing
burn′er
cham′ber
com-mode′
cov′er-let
count′er-pane
wash′stand

TOILET WORDS.

belt
brush
comb
ring
sash
watch
brace′let
buck′le
gir′dle
guard (gard)
neck′lace
trink′et
hair′pin
hand′ker-chief
per′fume
po-made
pow′der
tooth′brush

PARTS OF DRESS.

blouse
coat
gown
hood
hose
scarf
shawl
socks
vest
a′pron
cape
col′lar
cra-vat′
glove
jack′et
neck′tie
sur-tout′ (toot)
waist′coat
bon′net
gar′ment
gaunt′let (gont-let)
ker′chief
man′tle
pan-ta-loons
stock′ing
wrap′per
wrist-band

FOODS AND DRINKS.

bread
broth
cheese
hon′ey
bis′cuit (kit)
but′ter
cream
crack′er
choc′o-late
cof′fee
co′coa (ko′ko)
gru′el

sand′wich
soup
toast

cus′tard
dough′nut(do′nut)
pie

lem-on-ade′
milk
tea

FRUITS AND NUTS.

ap′ple
cher′ry
grape
or′ange
peach
pear (pare)
plum
prune

a′pri-cot
ba-nan′a
cit′ron
cur′rant
lem′on
mel′on
pine′apple
rai′sin (ra-zin)

a′corn
al′mond
chest′nut
co′coa-nut
fil′bert
pea′nut
pe-can′
wal′nut

IN THE GARDEN.

bean
beet
cab′bage
car′rot
on′ion (un′yun)
pea (pe)
rad′ish
squash
tur′nip

caul′(kol)i-flow-er
cel′e-ry
cu′cum-ber
egg′plant
let′tuce
pars′ley
po-ta′to
pump′kin
to-ma′to

as-par′a-gus
ar′ti-choke
bar′ber-ry
black′ber-ry
cran′ber-ry
goose′ber-ry
mul′ber-ry
rasp′ber-ry
straw′ber-ry

FAMILY WORDS.

aunt
broth′er
breth′ren
niece (nēs)
sis′ter
wife

fath′er
mam′ma
moth′er
neph′ew
pa′pa
un′cle

con-nec′tion
cous′in
daugh′ter
grand′fath-er
grand′moth-er
hus′band

FARM WORDS.

flail
pump
scythe (sīth)
sick′le
spout
trough (trof)

crib
fod′der
grain
hay
mow′er
straw

cul-ti-va′tor
gran′a-ry
har′row
plow
reap′er
rol′ler

WORK-SHOP.

awl
bench
gauge (gage)
plane
punch
shears
square
wrench

an′vil
bit
chis′el
forge
ham′mer
lathe
mal′let
vise

au′ger
bev′el
com′pass
gim′let
nip′pers
pin′cers
pul′ley
grind′stone

DRESS-GOODS.

chintz
gauze
lace
lin′en
sat′in
serge
silk

cam′let
cot′ton
mus′lin
pop′lin
thib′et (tib′et)
vel′vet
wool′en

al-pac′a
broad′cloth
cal′i-co
cam′bric
cash′mere
ging′ham
sat-i-net′

FOOD MEATS.

beef
ham
lamb
pork
steak (stake)
veal

cut′let
game
kid′ney
mut′ton
squab
tripe

ba′con
poul′try
sau′sage
sir′loin
spare′rib
ven′i-son

NAMES OF FISHES.

bass
cod
dace
eel
shad
smelt
sole
sprat

floun′der
gray′ling
had′dock
min′now
perch
roach
sar′dine
trout

hal′i-but
her′ring
mack′er-el
pick′er-el
sal′mon
stur′geon
tar′pon
tur′bot

AT THE STORE.

ale
braid
cloth
glue
hops
shot
starch
tar
yarn

black′ing
can′dles
feath′ers
flax′seed
match′es
pol′ish
tal′low
var′nish
wick′ing

clothes′pins
con-fec′tion-e-ry
cut′le-ry
dry′goods
grass′seed
gro′ce-ries
gun′pow-der
i′sin-glass
va-nil′la

POST-OFFICE AND RAILWAY.

bun′dle
freight
let′ter
mail
mon′ey
par′cel

bag′gage
doc′u-ment
en′gine
ex-press′
lug′gage
mag-a-zine′

brake′man
con-duc′tor
lo-co-mo′tive
news′pa-per
post′mas-ter
tel′e-gram

tick′et
train
pack′age
pam′phlet
tel′e-graph
val′en-tine

BUILDINGS.

chap′el
church
con′vent
mosque (mosk)
pal′ace
pris′on
tem′ple
cap′i-tol
cath-e′-dral
de′pot (de′po)
ho-tel′
pa-go′da
state′house
tav′ern
alms′house
ar′mo-ry
ar′se-nal
pen-i-ten′tia-ry
town′house
ware′house
work′house

TREES.

ash
ban′yan
beech
birch
ce′dar
cy′press
eb′o-ny
elm
fir
larch
oak
palm
pine
bay
box′wood
ca-tal′pa
chest′nut
ha′zel
hol′ly
ju′ni-per
lime
man′grove
ma′ple
spruce
thorn
yew
al′der
asp′en
bass′wood
hem′lock
hick′o-ry
lin′den
lo′cust
mag-no′lia
ma hog′a-ny
pal-met′to
pop′lar
syc′a-more
wil′low

IN THE FIELDS.

corn
flax
oats
rice
rye
wheat
bar′ley
clo′ver
hemp
maize
mil′let
sedge
buck′wheat
bul′rush
herd′grass
lu′cern
su′gar-cane
tim′o-thy

TAME ANIMALS.

cat
colt
don′key
horse
kid
mule
calf
cow
goat
lamb
ox′en
sheep
beast
cat′tle
herd′
heif′er (hef′fer)
stock
swine

WILD ANIMALS.

bear
deer
elk
li′on
lynx
mink
moose
pan′ther
ti′ger
wolf
fox
bea′ver
cam′el
er′mine
hy-e′na
jack′al
leop′ard
mar′ten
rac′coon
wea′sel (zel)
an′te-lope
buf′fa-lo
el′e-phant
ga-zelle
monk′ey
por′cu-pine
rein′deer
squir′rel
wood′chuck
ze′bra

BIRDS AND FOWLS.

crow
duck
ea′gle
goose
gull
hawk
hen
owl
quail
snipe
stork
thrush
wren
ca-na′ry
chick′en
cuck′oo (cook′oo)
grouse
lin′net
loon
mar′tin
o′ri-ole
par′rot
pig′eon (un)
spar′row
swal′low
tur′key
blue′bird
blue-jay
bob-o-link′
ca′pon
chick-a-dee′
con′dor
gold′finch
par′tridge
pul′let
rob′in
shel′drake
whip′-poor-will
wood′peck-er

PARTS OF THE BODY.

arm
brow
cheek
ear
eye
face
foot
fin′ger
gland
hand
knee
lip
mouth
nerve
nose
palm
thigh
thumb
vein
wrist
wind′pipe
beard
bone
chin
el′bow
flesh
heart
hair
hip
jaw
joint
lungs
neck
pal′ate
scalp
skin
skull
teeth
throat
tongue
tooth
waist
ab-do′men
an′kle
ar′te-ry
brain
eye′brow
eye′lash
eye′lid
fore′head
i′ris
liv′er
mus′cle
nos′tril
pu′pil
shoul′der
sin′ew
stom′ach
tem′ple
ten′don
tho′rax
ton′sil
ver′te-bra

WORKERS.

bank′er
bar′ber
cash-ier′
clerk
ca′ter-er
car′ver

butch′er
far′mer
host′ler
mil′ler
nurse
por′ter

drug′gist
mer′chant
mi′ner
pur′ser
sail′or
sales′man

gar′den-er
jan′i-tor
pho-tog′ra-pher
re-port′er
seam′stress
sta′tion-er

RULERS.

bish′op
chief
duke
king
pope
prel′ate
prince
queen

bar′on
duch′ess
em′per-or
em′press
mon′arch
pre′mier
prin′cess
sul′tan

au′to-crat
com-man′der
com′mo-dore
dic-ta′tor
gov′ern-or
leg-is-la′tor
pres′i-dent
sov′er-eign

IN SCHOOL.

bell
book
chart
clock
desk
map

black′board
fer′ule
pa′per
rat′tan
slate
shut′ter

as-sist′ant
chil′dren
dic′tion-ar-y
reg′is-ter
teach′er
ink′bot-tle

WEIGHTS AND MEASURES.

cent
inch
foot
mile
mill
rod
yard

dime
gill
peck
pence
pint
quart
tierce

bush′el
dram
gal′lon
min′ute
ounce
pound
sec′ond

COUNTING WORDS.

one
two
three
four
five
six
sev′en
eight
nine
ten

e-lev′en
twelve
thir′-teen
four′-teen
fif′teen
six′teen
sev′en-teen
eight′een
nine′teen
twen′ty

thir′ty
for′ty
fif′ty
six′ty
sev′en-ty
eight′y
nine′ty
hun′dred
thous′and
mil′lion

DAYS, MONTHS, SEASONS.

Note that the first letter in each of these words is a capital.

Sab′bath
Sun′day
Mon′day
Tues′day
Wed′nes-day
Thurs′day
Fri′day
Sat′ur-day

Jan′u-a-ry
Feb′ru-a-ry
March
A′pril
May
June
Ju-ly
Au′gust

Sep-tem′ber
Oc-to-ber
No-vem′ber
De-cem′ber
Win′ter
Spring
Sum′mer
Au′tumn

COLORS.

blue
green
in′di-go
li′lac
or′ange
red
yel′low

am′ber
brown
car′mine
crim′son
drab
pink
pur′ple

lav′en-der
mad′der
ma-roon′
sal′mon
scar′let
ver-mil′ion
vi′o-let

NAMES OF MEN.

Ab′ner
Ad′am
Al′bert
Al′ex-an′der
Al′fred
Al′len
Am′brose
A′mos
An′drew
Ar′thur
Au-gus′tus
Ben′ja-min
Bar′nard
Ca′leb
Charles
Clar′ence
Claude
Con′rad
Cy′rus
Dan′i-el
Da′vid
Don′ald
Ed′gar
Ed′ward
E′li
E-li′sha
El′mer

Er′nest
E′than
Ez′ra
Fe′lix
Fran′cis
Frank
George
Gid′e-on
Gil′bert
Har′old
Hen′ry
Her′bert
Her′man
Hi′ram
Hor′ace
Hu′bert
Hugh
I′saac
Is′ra-el
Ja′cob
James
Jas′per
Jes′se
John
Jo′seph
Josh′u-a
Law′rence

Le′vi
Lew′is
Lou′is
Luke
Mark
Mat′thew
Mo′ses
Na′than
Ol′i-ver
Ow′en
Paul
Pe′ter
Phil′ip
Ralph
Reu′ben
Rich′ard
Rob′ert
Sam′u-el
Si′mon
Ste′ven
The′o-dore
Thom′as
Tim′o-thy
U-ri′ah
Wal′ter
Wil′li-am
Zach-a-ri′ah

NAMES OF WOMEN.

Ab'i-gail
A'da
Ad'a-line
Ag'nes
Al'ice
A-me'li-a
Ann
An'ne
Bar'ba-ra
Be'a-trice
Belle
Ber'tha
Bes'sie
E'dith
E-liz'a-beth
E-li'za
El'la
Em'e-line
Em'i-ly
Em'ma
Es'ther
Eth'el
Eu-ge'nie
E'va
E-van'ge-line
Flo'ra
Ju'li-a
Kate
Kath'er-ine
Lau'ra
Le-ti'ti-a
Lil'i-an
Loui'sa
Lu'cy
Ma'bel
Mar'cel-la
Mar'ga-ret
Mar'tha
Ma'ry
Blanch
Car'o-line
Cath'a-rine
Ce'li-a
Char'lotte
Clar'a
Con'stance
Co'ra
Cor-ne'-li-a
Deb'o-rah
Di-an'a
Do'ra
Dor'cas
Dor'o-thy
Flor'ence
Fran'ces
Ger'trude
Grace
Han'nah
Har'ri-et
Hel'en
Hes'ter
I'da
I'rene
Is-a-bel'la
Jane
Jo-an'na
Jo'seph-ine
May
Nan'cy
Pau'line
Phe'be
Pol'ly
Ra'chel
Re-bec'ca
Sa-lome'
Sa'rah
Su'san
The-re'sa
Vic-to'ri-a
Vi-o'la
Vir-gin'i-a

WORDS PRONOUNCED ALIKE, BUT SPELLED DIFFERENTLY.

adz, cutting tool.	**adds,** doth add.
ail, to be ill.	**ale,** fermented liquor.
air, atmosphere.	**heir,** legal representative.
aisle, passage-way.	**isle,** island.
all, entire.	**awl,** pointed instrument.
altar, raised structure.	**alter,** to change.
arc, part of a circle.	**ark,** chest, vessel.
ascent, upward slope.	**assent,** agreement.
auger, boring tool.	**augur,** to foretell.
bad, wicked.	**bade,** did bid.
bail, security.	**bale,** package, bundle.
ball, round thing.	**bawl,** to cry out.
bare, naked.	**bear,** to support.
barren, sterile.	**baron,** nobleman.
base, mean.	**bass,** musical part.
bask, to lie in warmth.	**basque,** dress jacket.
bate, to abate.	**bait,** a lure.
batten, to fatten.	**baton,** a staff.
bay, a sea inlet.	**bey,** a Turkish official.
be, exist.	**bee,** winged insect.
beach, a shore.	**beech,** a tree.
beat, to strike.	**beet,** a vegetable.
beer, fermented liquor.	**bier,** burial frame.
bell, ringing vessel.	**belle,** a fair lady.
berry, a small fruit.	**bury,** cover out of sight.
berth, ship sleeping-room.	**birth,** bringing forth.
billed, was charged.	**build,** to construct.
bin, a receptacle.	**been,** have existed.
bite, seizing with teeth.	**bight,** angle, corner.
blew, did blow.	**blue,** a color.
blight, to mildew.	**blite,** a genus of herbs.
boar, a male hog.	**bore,** to make a hole.
board, sawed timber.	**bored,** annoyed.
bolder, more bold.	**boulder,** a round rock.
boll, seed pod.	**bowl,** small vessel.
born, delivered.	**borne,** carried.
borough, incorporated town	**burrow,** to dig.
bot, a worm.	**bought,** did buy.
bow, anything bent.	**beau,** an escort.
bow, to courtesy.	**bough,** twig, limb.
boy, male child.	**buoy,** floating mark.
brake, thicket.	**break,** interruption.
breach, to break.	**breech,** the buttock.
bread, baked flour.	**bred,** brought up.
brows, the eyebrows.	**browse,** to nibble branches.
bruit, to spread abroad.	**brute,** an animal.
bus, an omnibus.	**buss,** to kiss.
but, except, save.	**butt,** large cask.
by, near, next to.	**buy,** to purchase.
calendar, almanac.	**calender,** to make smooth.
canon, a rule.	**cannon,** large gun.
canvas, strong cloth.	**canvass,** to solicit.
carat a weight. **caret,** mark.	**carrot,** a root.
cash, ready money.	**cache,** hiding place.
cast, to throw.	**caste,** rank.
caster, vial, cruet.	**castor,** beaver fur.
capital, chief city.	**capitol,** state-house.
cause, to bring about.	**caws,** crow cries.
cede, to transfer.	**seed,** a ripened ovule.
cheap, low-priced.	**cheep,** to chirp.
ceil, to overlay.	**seal,** make fast.
ceiling, overhead lining.	**sealing,** making fast.
cell, close room.	**sell,** dispose of.
cent, a coin.	**scent,** smell.
cents, small coins.	**sense,** a faculty.
censer, perfume vessel.	**censor,** a critic.
cere, to wax. **seer,** wise man.	**sear,** to wither.
cereal, a grain.	**serial,** running story.
cit, a citizen.	**sit,** be seated.
cite, to quote.	**sight,** power of vision.

claws, nailed toes.	**clause,** sentence.
climb, to mount.	**clime,** climate.
coat, outer vestment.	**cote,** dove house.
coin, piece of money.	**coign,** an angle.
coke, charred coal.	**coak,** a tenon.
cold, low temperature.	**coaled,** took on coal.
colonel, military officer.	**kernel,** single seed.
complement, what completes.	**compliment,** word of approval.
cord a string.	**chord,** musical tone.
core, inner part	**corps,** a body of men.
core, inner part.	**chore,** small job.
council deliberative body.	**counsel,** advice.
course, a road.	**coarse,** not refined.
cousin, uncle's child.	**cozen,** to cheat.
cue, billiard stick.	**queue,** tail of hair.
currant, a fruit.	**current,** onward motion.
crease, fold.	**creese,** dagger.
cymbal, musical instrument.	**symbol,** a type.
dam, barrier.	**damn,** oath.
Dane, of Denmark.	**deign,** to esteem worthy.
day, after sunrise.	**dey,** a governor.
demean, to behave.	**demesne,** manor place.
desert, to forsake.	**dessert,** last dinner course.
dew, moisture.	**due,** payable.
die, to expire.	**dye,** to color.
doe, female deer.	**dough,** unbaked bread.
done, completed.	**dun,** a color.
droop, hang downward.	**drupe,** pulpy fruit.
dual, double.	**duel,** battle between two.
dust, earthy particles.	**dost,** do.
dying, expiring.	**dyeing,** coloring.
earn, to deserve.	**urn,** a vessel.
fain, to be glad, **fane,** temple.	**feign,** pretend.
fair, unblemished.	**fare,** price of a passage.
faun, a deity.	**fawn,** flatter.
feat, an act.	**feet,** walking parts.
felloe, wheel rim.	**fellow,** associate.
ferule, flat piece of wood.	**ferrule,** metal cap.
fir, a tree.	**fur,** soft hair.
fizz, to hiss.	**phiz,** face
flea, jumping animal.	**flee,** run away.
flour, ground grain.	**flower,** a bloom.
foul, noxious.	**fowl,** a large bird.
fore, in front.	**four,** twice two.
forth, away from.	**fourth,** after third.
freeze, to congeal.	**frieze,** a coarse cloth.
gall, bitter liquid.	**Gaul,** ancient country.
gamble, playing for stakes	**gambol,** to frisk.
gate, an opening.	**gait,** movement.

gild, to cover with gold.	**guild,** a fraternity.
gilt, covered with gold.	**guilt,** criminality.
glacier, ice river.	**glaizer,** glass-setter.
grate, to rub harshly.	**great,** renowned.
greave, armor.	**grieve,** to sorrow.
guest, one entertained.	**guessed,** supposed.
hail, frozen rain.	**hale,** hearty.
hall, meeting place.	**haul,** to draw.
hair, head covering.	**hare,** wild animal.
hart, male deer.	**heart,** pulsating organ.
heal, to cure.	**heel,** hinder foot-part.
hear, listen to.	**here,** in this place.
hew, to cut.	**hue,** a color.
hie, hasten.	**high,** elevated.
him, objective of he.	**hymn,** sacred song.
ho! an exclamation.	**hoe,** garden implement.
hoar, whitish.	**whore,** a lewd woman.
hoop, circular band.	**whoop,** loud shout.
hole, opening.	**whole,** all.
I, pronoun. **Aye,** yes.	**eye,** organ of sight.
idle, lazy. **idol,** image.	**idyl,** short poem.
in, within.	**inn,** public house.
indict, charge with crime.	**indite,** dictate.
jam, a crush.	**jamb,** door part.
kame, hill.	**came,** did come.
key, unlocking instrument.	**quay,** a wharf.
kill, to slay.	**kiln,** furnace.
knows, has knowledge of.	**nose,** organ of smell.
lac, resin.	**lack,** to be without.
laff, a fish.	**laugh,** to show mirth.
lam, to strike.	**lamb,** young sheep.
lane, narrow way.	**lain,** did lay.
lap, kneepart.	**Lapp,** of Lapland.
laps, knee parts.	**lapse,** to pass away.
lea, grassy field.	**lee,** sheltered side.
leach, to wash.	**leech,** sucking animal.
leaf, foliage.	**lief,** willingly.
leak, to admit water.	**leek,** bulbous plant.
led, did lead.	**lead,** a heavy metal.
limb, tree-branch.	**limn,** to draw.
load, a burden.	**lode,** metallic vein.
loan, a lending.	**lone,** by one's self.
loath, unwilling.	**loathe,** to hate.
loot, rob.	**lute,** musical instrument.
lose, cease to have.	**loose,** to untie.
made, manufactured.	**maid,** a girl.
main, principal part.	**mane,** heavy hair.
male, masculine.	**mail,** armor.
mall, a walk.	**maul,** wooden hammer.
mantel, a shelf.	**mantle,** a cloak.
mark, visible sign.	**marque,** a license.
marshal an officer.	**martial,** warlike.
martin, a bird.	**marten,** fur animal.
mat, floor covering.	**matte,** slag.
maze, a winding.	**maize,** Indian corn.

mead, a drink.	**meed,** reward.
mean, stingy.	**mesne,** intermediate.
meat, flesh.	**meet,** to come together.
medal, a reward.	**meddle,** to intrude.
metal, refined ore.	**mettle,** spirit, courage.
miner, who mines.	**minor,** below age.
mind, intellect.	**mined,** dug out.
mist, thin rain.	**missed,** failed to hit.
mite, small thing.	**might,** strength.
nap, a short sleep.	**knap,** a button.
nave, a hub.	**knave,** a rascal.
need, necessity.	**knead,** to work dough.
niece, brother's daughter.	**gneiss,** a mineral.
night, darkness.	**knight,** a champion.
nit, louse egg.	**knit,** to loop yarn.
nock, to notch.	**knock,** a hard stroke.
none, not any.	**nun,** a devoted woman.
not, negative.	**knot,** a tie.
ode, a lyric poem.	**owed,** did owe.
ordinance, a statute.	**ordnace,** heavy weapons.
ore, raw mineral.	**oar,** rowing implement.
our, pertaining to us.	**hour,** sixty minutes.
pain, suffering.	**pane,** light of glass.
palate, roof of the mouth.	**pallet,** bed of straw.
pale, lacking color.	**pail,** water vessel.
pare, shave off. **pair,** two.	**pear,** fruit.
peace, repose.	**piece,** a part of.
peak, summit. **peek,** peep.	**pique,** offend.
peal, a loud sound.	**peel,** to strip off.
pedal, foot lever.	**peddle,** to sell.
peer, an equal.	**pier,** bridge support.
phrase, term.	**fraise,** a defense.
pistil, seed organ.	**pistol,** a weapon.
place, definite point.	**plaice,** a fish.
plain, level space.	**plane,** smoothing tool.
plat, flat ground.	**plait,** pleat.
plate, a dish.	**plait,** to pleat.
plum, a fruit.	**plumb,** perpendicular.
pole, tall piece of wood.	**poll,** to enumerate.
populace, the people.	**populous,** thickly peopled.
prophecy, prediction.	**prophesy,** to foretell.
pore, minute orifice.	**pour,** to send forth.
port, a harbor.	**Porte,** the Turkish court.
praise, to commend.	**prays,** he petitions.
pray, to make petition.	**prey,** booty.
quire, twenty-four sheets.	**choir,** musical body.
rack, a hay frame.	**wrack,** seaweed.
rabbit, wild animal.	**rabbet,** groove, joint.
racket, confused noise.	**racquet,** a game.
rail, to scoff.	**rale,** a chest sound.
rain, falling drops.	**reign,** to rule. **rein,** a strap.

raise, to lift up.	**raze,** to tear down.
rap, to knock on.	**wrap,** an outer garment.
red, a color.	**read,** did read.
read, to peruse.	**reed,** coarse grass.
reave, to rob.	**reeve,** an officer.
reck, to care for.	**wreck,** to destroy.
rest, quiet.	**wrest,** to pull away.
retch, to strain.	**wretch,** miserable person.
right, not wrong.	**wright** a mechanic.
rime, hoar-frost.	**rhyme,** measured verse.
ring, circular area.	**wring,** to squeeze hard.
rite, a ceremony.	**write,** to inscribe.
road, a highway.	**rode,** did ride.
roam, to wander.	**Rome,** Italian city.
roar, a deep sound.	**rore,** dewy.
roc, monstrous bird.	**rock,** large stone.
roe, fish spawn.	**row,** propel a boat.
role, assumed part.	**roll,** to move by turning.
rood, a measure.	**rude,** bad mannered.
room, extent of place.	**rheum,** mucous discharge.
rote, repetition.	**wrote,** did write.
rough, not smooth.	**ruff,** fluted collar.
rung, a round.	**wrung,** squeezed hard.
rye, a grain.	**wry,** distorted.
sack, a bag.	**sacque,** kind of coat.
sail, ship canvas.	**sale,** act of selling.
sane, of sound mind.	**seine,** fishing net.
scene, place of occurrance.	**seen,** was observed.
scull, an oar.	**skull,** brain case.
sea, body of water.	**see,** to perceive.
seal, to shut close.	**seel,** to blind.
seam, line of junction.	**seem,** to appear.
sear, to wither.	
sere, withered.	**seer,** a wise man.
serge, a cloth.	**surge,** to roll high.
serf, a bondman.	**surf,** ocean swell.
shear, to clip.	**sheer,** vertical.
shew, to show.	**shoe,** foot covering.
shoot, young plant.	**chute,** trough, slide.
sign, a token.	**sine,** measure of an arc.
sink, to descend.	**cinque,** five.
sloe, a plum.	**slow,** not swift.
so, in that manner.	**sew,** to stitch.
soak, to steep.	**soke,** a franchise.
soar, to fly high.	**sore,** painful.
sole, bottom of the foot.	**soul,** spirit.
some, indefinite quantity.	**sum,** account.
son, male child.	**sun,** central planet.
soot, carbon powder.	**suit,** legal process.
stake, pointed piece of wood.	**steak,** cut of beef.
stationary, not moving	**stationery,** writing articles.
steal, to filch.	**steel,** hardened iron.
steer, to guide.	**stere** a measure.
step, foot movement.	**steppe,** elevated plain.
sticks, pieces of wood.	**Styx,** river of Hades

stile, revolving gate.	**style,** mode.
stoop, to bend down.	**stupe,** a compress.
strait, narrow pasage.	**straight,** not crooked.
subtle, artful.	**subtile,** nice, fine.
succor to assist.	**sucker,** a kind of fish.
swath, line of cut grass.	**swathe,** to bandage.
tacks, small nails.	**tax,** imposed charge.
tale, a story.	**tail,** rear appendage.
taper, small light.	**tapir,** wild animal.
tare, a weed.	**tear,** to rend.
taut, stretched tightly.	**taught,** did teach.
tea, a table drink.	**tee,** small earth mound.
team, hitched animals.	**teem,** to abound.
tear, limpid eye-drop.	**tier,** row of seats.
terce, third part.	**terse,** brief, concise.
tern, water fowl.	**turn,** move around.
the, definite article.	**thee,** objective of thou.
their, of them.	**there,** in that place.
threw, did throw.	**through,** from end to end.
throe, violent pain.	**throw,** to fling.
tide, rising of water.	**tied,** fastened.
time, duration.	**thyme,** garden plant,
to, toward. **too,** more than.	**two,** twice one.
toe, foot member.	**tow,** coarse flax.
ton, a weight.	**tun,** a large cask.

troche, medical lozenge.	**trochee,** metrical foot.
troop, a body of soldiers.	**troupe,** stage company.
vain, proud. **vane,** weather cock.	**vein,** blood vessel.
vale, valley.	**veil,** face cover.
vice, defect, fault.	**vise,** holding implement.
wail, mourful outcry.	**wale,** streak, mark.
wain, a wagon.	**wane,** to wax less.
waist, middle part.	**waste,** to destroy.
wait, to stay for.	**weight,** heaviness.
ware, articles for sale.	**wear,** the thing worn.
wave, swell of water.	**waive,** to relinquish.
way, will, road.	**weigh,** ascertain weight.
weak, feeble.	**week,** seven days.
weald, wooded land.	**wield,** use, handle.
wean, to detach.	**ween,** to think.
weather, atmosphereic condition.	**wether,** male sheep.
yew, a tree. **You,** yourself.	**ewe,** female sheep.

STATE AND TERRITORIAL NAMES WITH THEIR ABBREVIATIONS AND CAPITALS.

Alabama	Ala.	Montgomery.
Alaska	Alas.	Sitka.
Arizona	Ariz.	Phœnix.
Arkansas	Ark.	Little Rock.
California	Cal.	Sacramento.
Colorado	Col. or Colo.	Denver
Connecticut	Conn. or Ct.	Hartford.
Delaware	Del.	Dover.
District of Columbia	D. C.	Washington.
Florida	Fla. or Flor.	Tallahassee.
Georgia	Ga.	Atlanta.
Guam		Agana.
Hawaiian Islands		Honolulu.
Idaho	Id.	Boise.
Indian Territory	Ind. Ter. or Ind. T.	(Now Oklahoma.)
Illinois	Ill. or Ills.	Springfield.
Indiana	Ind.	Indianapolis.
Iowa	Io.	Des Moines.
Kansas	Kan. or Kans.	Topeka.
Kentucky	Ken. or Ky.	Frankfort.
Louisiana	La.	Baton Rouge.
Maine	Me.	Augusta.
Maryland	Md.	Annapolis.
Massachusetts	Mass.	Boston.
Michigan	Mich.	Lansing.
Minnesota	Minn.	St. Paul.
Mississippi	Miss.	Jackson.
Missouri	Mo.	Jefferson City.
Montana	Mont.	Helena.
Nebraska	Neb.	Lincoln.
Nevada	Nev.	Carson City.
New Hampshire	N. H.	Concord.
New Jersey	N. J.	Trenton.
New Mexico	New M.	Santa Fe.
New York	N. Y.	Albany.
North Carolina	N. C.	Raleigh.
North Dakota	N. Dak.	Bismarck.
Ohio	O.	Columbus.
Oklahoma	Okla.	Guthrie.
Oregon	Ore. or Oreg.	Salem.
Pennsylvania	Pa. or Penn.	Harrisburg.
Philippine Islands	P. I.	Manila.
Rhode Island	R. I.	Providence.
Porto Rico	P. R.	San Juan.
South Carolina	S. C.	Columbia.
South Dakota	S. Dak.	Pierre.
Tennessee	Tenn.	Nashville.
Tutuila Islands		
Texas	Tex.	Austin.
Utah	Ut.	Salt Lake City.
Vermont	Vt.	Montpelier.
Virginia	Va.	Richmond.
Washington	Wash.	Olympia.
West Virginia	W. Va.	Charleston
Wisconsin	Wis.	Madison.
Wyoming	Wyo.	Cheyenne.

OUR ENGLISH SPEECH

ELEMENTARY ENGLISH.

One bright winter morning I saw two boys start from their home with their sleds. They went down the street just ahead of me, and I heard them talking happily about the snow, their sleds, and the fun they were expecting to have. Here are some of the things they said:

1. It snowed all night.
2. How cold it is!
3. See my new sled.
4. Father gave it to me.
5. Where did he buy it?
6. He brought it from the city.
7. Here comes John with his sled.
8. Do you think we can beat him down the hill?
9. What a jolly time we will have!
10. Look out for that horse.

Each one of the ten remarks, which are printed here, contains a complete thought.

A sentence is a complete thought expressed in words. So we may say that we have here ten sentences spoken by the boys.

Look at each of the following lines and decide which of them are sentences. To help you, I will tell you that three of them are not sentences, because they do not express **complete** thoughts.

1. Two birds made a nest.
2. It was made of yarn.
3. Among the branches.
4. What is in the nest?
5. Do not touch the eggs.
6. What pretty blue eggs they are!
7. Four baby birds.
8. The little birds soon flew away.
9. How long did they.

Now try making some sentences of your own about a bull, a doll, a horse, a dog, a clock.

Make sentences using the words sing, run, jump, swim, fly, play.

KINDS OF SENTENCES.

Look carefully at the ten sentences spoken by the boys at the beginning of this lesson, and you will notice that the thoughts are not all expressed in the same way. Four of them (1, 4, 6, 7) are used simply to tell something; two of them (5, 8) ask questions; two of them (3, 10) contain a sort of command; the remaining two (2, 9) are said in such a way as to show surprise or excitement.

So, you see, we have four kinds of sentences. The first kind, being used to tell or declare something, is called a **declarative** sentence. The second kind, being used to ask questions, is called an **interrogative** sentence.

The third kind, being used in commands or requests, is called an **imperative** sentence. The fourth kind, being used in making exclamations, is called an **exclamatory** sentence.

CAPITALS AND PUNCTUATION.

The first word of every sentence should begin with a capital letter. Look at the sentences we have been studying, and you will see that we have been careful to begin every sentence in that way. Notice, however, that they do not all have the same kinds of marks at the end. A **declarative** sentence ends with a period.

An **imperative** sentence also ends with a period.

An **interrogative** sentence ends with an interrogation mark.

An **exclamatory** sentence ends with an exclamation mark.

Write sentences about a pony, a kitten, an apple, a picture, rain. Try to use different kinds of sentences. Be sure to begin every sentence with a capital letter and to end it with the proper mark of punctuation.

Copy the following sentences, decide what kind of a sentence each is, and put the proper mark of punctuation at the end of each. Notice that every sentence begins with a capital letter:

In the country stood a pleasant house

A little garden lay between the house and the road

Near the gate grew a little daisy

Do you know what a daisy looks like

It looks like a star

How pretty it is

To help you in studying the sentences thus far, we have begun each new sentence in the exercise on a new line. This is not the way sentences are usually printed. If there is room for more words, the next sentence generally begins on the same line with the sentence just finished. In the exercise given below are six sentences, but the marks of punctuation are omitted. Pick out the sentences and punctuate them.

Near the daisy grew a number of garden flowers They were very proud They did not notice the daisy Do you think the daisy felt sad The daisy heard a bird singing in the sky How beautiful the song was

Now, let us try one more exercise in writing sentences correctly. This time we shall not only omit the marks of punctuation, but we shall also omit all capital letters. Study the lines carefully. Decide where each sentence begins and where it ends. Begin the first word of each sentence with a capital letter, and place the proper mark of punctuation after the sentence.

The daisy heard a lark singing the lark flew down to the garden which flowers did he come to see he did not go near the garden flowers he hopped into the grass near the daisy the daisy trembled for joy the lark sang a beautiful song to the daisy how happy the daisy felt

MORE ABOUT CAPITAL LETTERS.

Read the following sentences, noting carefully the use of capital letters. Before I went to the country, I had seen very few wild flowers. My father and I visited the country last summer. As we walked through the fields I asked him the names of the flowers. In this way I soon learned to know many flowers.

We have here four sentences, each beginning with a capital letter. Notice that the word "I" is also written with a capital. This word should never be written with a small letter.

THE PARTS OF A SENTENCE.

A complete sentence consists of two parts, called the **subject** and the **predicate**.

The **subject** points out the person, place or thing about which something is said.

The **predicate** tells what is said about the subject.

In the following sentences the first word is the subject and the second word the predicate.

Fire burns. Water flowed. Crickets chirp. Rain fell. Harry runs. Stars shine.

Sometimes several words are needed to form a predicate, as in the following sentences. The subject is separated from the predicate by a vertical line.

Horses|can run. Soldiers|have fought. Leaves|were flying. Accidents|will happen. Lights|are burning. Words|may be written.

NOUNS.

Notice that the subject in every sentence we have just used is the name of something. Words that are the names of persons, places, or things are called **nouns**. The word noun means name. The following list of ten words contains eight nouns. See whether you can pick them out.

Trenton, song, is, bud, snow, mountain, try, stone, robin, tree.

Write ten nouns which are the names of things found in a house.

Write ten nouns that are the names of persons or places.

PRONOUNS.

Harry has a new ball. *He* likes to play with *it*. *His* friends play with *him*. *They* have a jolly time.

Notice the words in italics. Each one of them is used instead of a noun. If we used the nouns the last three sentences would read: Harry likes to play with the ball. Harry's friends play with Harry. The friends have a jolly time.

He, it, his, him and *they* are called pronouns. A pronoun is a word used instead of a noun. There are eight pronouns in the following paragraph. See whether you can pick them out.

One day a wise man was sitting at the king's table when Prince Henry came into the room. He saw a frown on the boy's face, and he said to the king, "I can make your son happy, and change his frown into smiles if you will send him into the country to live with me."

VERBS.

A dog *ran* into our house. The day *was* rainy. He *shivered* with cold. My father *pitied* the dog. He *gave* the dog a place under the stove. Soon the dog *was* warm and dry. He *slept* for a while. Then he *played* with us. He still *lives* at our house.

Notice the words in italics. The words *ran, shivered, pitied, gave* and *played* express action. The word *was* expresses existence or being. The words *slept* and *lives* express the state or condition of existence. All of these words are called verbs. A verb is a word that asserts action, being, or state of being.

There are eight verbs in the following paragraph. See whether you can find them.

Harry climbed into the boat. He raised the sail. The waves were high. He was not afraid. He sailed the boat. The waves dashed over the side. He traveled many miles. The next day he came home.

ADJECTIVES.

The subject of a sentence always contains a noun or pronoun, or words used like a noun. This is called the simple subject. Very often the subject contains other words which modify or change the meaning of the simple subject. Notice how words are added to the simple subject in the following sentences:

1. Snowflakes|fell.
2. White snowflakes|fell.
3. Beautiful, white snowflakes|fell.
4. Many beautiful, white snowflakes|fell.

The words *many, beautiful* and *white,* which are used to modify the meaning of the noun *snowflakes,* are called adjectives. An adjective is a word used to modify the meaning of a noun or a pronoun.

Snowflakes is the simple subject of each sentence. The simple subject with its modifying words is called the complete subject.

ADVERBS.

The predicate of a sentence always contains a verb. This is called the simple predicate. Other words are often joined to the simple predicate to modify its meaning. Usually, these words contain the idea of *how, when,* or *where.*

Notice the words in italics in the following sentences. Each one modifies a verb and is called an adverb.

The deer|ran *swiftly.*
Winter|will come *soon.*
Many boys|play *there.*
The sleigh|glides *smoothly.*
The bird|*never* sang.
You|may bring it *here.*

Sometimes adverbs modify adjectives or other adverbs, as in the following sentences:

The train ran *very* swiftly.
Too many cooks spoil the broth.
Very modifies the adverb swiftly.
Too modifies the adjective many.

PHRASE MODIFIERS.

You have learned that adjectives and adverbs are used as modifiers. Sometimes a group of words, called a *phrase,* is used as a modifier.

In the sentence: My book is *here, here* is an adverb modifying *is.*

In the sentence: My book is *in this place,* the phrase *in this place* is used to do just the work that the adverb *here* did in the other sentence. This phrase is, therefore, called an adverbial modifier.

He is a wealthy man.
He is a man of wealth.

Notice that the adjective *wealthy* in the first sentence and the phrase *of wealth* in the second sentence are both used to modify the meaning of the word *man.* Therefore, we call *of wealth* an adjective modifier.

Notice the phrases in italics in the following sentences. Three of them are adjective modifiers, because they modify nouns, and five of them are adverbial modifiers, because they modify verbs.

Decide what kind of modifier each phrase is by determining what it modifies.

My friend lives *in England.*
The leaves *of the maple* have changed color.
We walked *beside the river.*
The flower grew *in the meadow.*
The top *of the mountain* is covered *with snow.*
A basket *of fruit* stood *on the table.*

PREPOSITIONS.

Nearly all phrases contain a principal word preceded by an introductory word.

Mary went *to Boston.*

In the phrase *to Boston, Boston* is the principal word. The phrase is introduced by the word *to,* which shows what relation the word *Boston* bears to the word *went.* If the sentence reads, Mary went from Boston, the word *from* shows a different relation between *Boston* and *went.*

Words which introduce phrases and show relations, as *to* and *from* do in these sentences, are called *prepositions.* Notice how the relation between *table* and *walked* changes as we use *under, near, across,* or *beside,* instead of *on* in the sentence: The cat walked on the table.

Every phrase in the sentences in the last chapter is introduced by a preposition.

CONJUNCTIONS.

John *and* Harry have a garden.
They raise beans *and* corn.
They hoe *and* water the plants.
They begin work in March *or* in April.

Notice that in the first sentence *and* joins the noun *John* to the noun *Harry;* in the second sentence it joins the noun *beans* to the noun *corn;* in the third sentence *and* joins the verb *hoe* to the verb *water;* in the last sentence *or* joins the phrases *in March* and *in April.*

These words which join words and phrases are called conjunctions. Sometimes two sentences are joined into one by using a conjunction, as in the following:

The boys work hard.
They never complain.
The boys work hard, *but* they never complain.

Each of the parts of the sentence connected by *but* is called a clause.

INTERJECTIONS.

In the following sentence, notice that the italicized words are mere exclamations. They express strong feeling and are usually followed by an exclamation mark.

Ah! there are our friends.
Hello! who is that?
Well! that is strange.
Pshaw! I don't believe it.

REVIEW OF THE PARTS OF SPEECH.

A noun is the name of a person, a place, or a thing.

A verb is a word that expresses action, being, or state of being.

A pronoun is a word used instead of a noun.

An adjective is a word used to modify the meaning of a noun or a pronoun.

An adverb is a word used to modify the meaning of a verb, an adjective, or another adverb.

A preposition is a word which introduces a phrase and shows the relation of the principal word in the phrase to the word whose meaning it modifies.

A conjunction is a word used to connect words, phrases or clauses.

An interjection is a word used to express strong emotion.

Every word in our language may be classified under these eight parts of speech.

COMPLEMENTS.

You have learned that the predicate always contains a verb, and may have word or phrase modifiers. In the following sentences the words in italics are neither verbs nor phrase modifiers, yet they are necessary in order to complete the meaning of the predicate, and are, therefore, called complements of the predicate.

James|threw the *ball.*
The apples|are *ripe.*
Wellington|was a *soldier.*

COMPOUND SUBJECTS AND PREDICATES.

Two or more words connected by conjunctions may be used as subjects or predicates. These are called compound subjects or compound predicates. Notice the following sentences:

Lakes and *rivers*|beautify the scenery.
The musician|*played* and *sang* beautifully.
Grass and flowers|*grew* and *flourished.*

PROPER NAMES.

Many years ago, James Watt, who lived in England, made the first steam engine. Some time afterward George Stephenson made an engine that would run along upon rails. His son, Robert, helped to build a locomotive named the Rocket. One of the first locomotives used in the United States was called John Bull. In the year 1845 there were less than one hundred locomotives in the entire State of Pennsylvania. Now one may see hundreds of locomotives in large cities, such as New York, Philadelphia, Boston and Chicago.

You have learned why capital letters are used to begin the words Many, Some, His, One, In and Now in the sentences given above. Notice that each of the other capitalized words is a noun and is the particular name of a person, a place, or a thing. Such words are called *proper* *nouns.* Notice that proper nouns may consist of one word, or more than one word. Sometimes proper names are made up of several important words joined to each other by some less important words. In this case only the important words are capitalized; as, for example, Gulf of Mexico, Lake of the Woods, Isthmus of Panama.

WORDS MADE FROM PROPER NAMES.

In many cases adjectives are derived from proper names. These are also begun with capital letters. Notice the following examples:

Noun.—France, America, Britain, Greece.

Adjective.—French, American, British, Greek.

Write the story of the discovery of America by Columbus, paying special attention to the rules for capitals and punctuation which you have learned.

ABBREVIATIONS.

For convenience in writing, we often shorten words by omitting a number of the letters, keeping only enough to indicate our meaning.

The word abbreviation means a shortening. Every abbreviation should be followed by a period. Below are given a few examples of familiar abbreviations:

Jan.—January.
Mr.—Mister.
amt.—amount.
Dr.—Doctor.
Capt.—Captain.
N. Y.—New York.
Cal.—California.
Jas.—James.
qt.—quart.
bal.—balance.
cor.—corner.
mfr.—manufacturer.
mo.—month.
mdse.—merchandise.
doz.—dozen.
ft.—foot.

Rewrite the following, using abbreviations for all words printed in italics. When in doubt about the correct form, consult a good dictionary:

George Washington was born in *Virginia* on *February* 22, 1732.

Lumber costs six cents per *foot.*

Jones and *Brother* have a store in Boston, *Massachusetts.*

Professor Morris was talking to *Colonel* Potter and *Doctor* Jenkins.

William Wilson

To *Charles* Mapes, *Debtor.*

To 1 *peck* apples	$0.15
1 *gallon* vinegar	.20
2 *dozen* eggs	.36
1 *package* oatmeal	.16
Amount	$0.87

CONTRACTIONS.

Abbreviations are made for convenience in writing only. In speaking we often shorten certain words by leaving out certain sounds, usually retaining the first and the last sounds. In writing, also, we sometimes retain only the first and last parts of words, omitting the rest for the sake of convenience. Such shortenings of words are called contractions, and the omission of part of the word is shown by the use of a mark called **apostrophe.** For example, the word *not* is often contracted and joined to another word, as in can't, didn't, wouldn't.

Write out in full the following contracted expressions:

You'll, I'm, I'd, 'twas, we're, e'er, sha'n't, where's, he's, they're, o'er, ne'er.

ANOTHER USE OF THE APOSTROPHE.

The apostrophe is often used to show ownership. Notice the following sentences:

1. I found Harry's hat.
2. Wilson's store is very large.
3. The horse's mane is long.
4. The birds' nests are in the tree.

Harry's hat means the hat belonging to Harry.

Wilson's store means the store owned by Mr. Wilson.

The *horse's mane* belongs to the horse, and the *birds' nests* belong to the birds.

When the owner is only one person or thing, ownership is usually shown by an apostrophe followed by **s.**

To avoid a repetition of hissing sounds, when **s** has already been added to a word to indicate that more than one is meant, ownership is shown by adding only the apostrophe. Notice the sentence about the birds' nests.

Write sentences using the following words with the proper signs to show ownership:

Friends, children, man, driver, soldiers, doll, flower, sun, army country.

LETTER-WRITING.

Cape May, New Jersey,
October 10, 1907.

Dear Tom:

My father bought me a dog last week. It is a little beauty. It is nearly all white and has a beautiful tail that looks like a plume.

His name is Don. He seems to like me, but yet we have to tie him, or he will run away.

Maybe, when he is here longer he will stay at home.

Will you not come to see Don?

Your friend,
Ralph Joy.

Look carefully at the letter above and notice its different parts.

First comes the heading, which shows where the letter was written and when it was written.

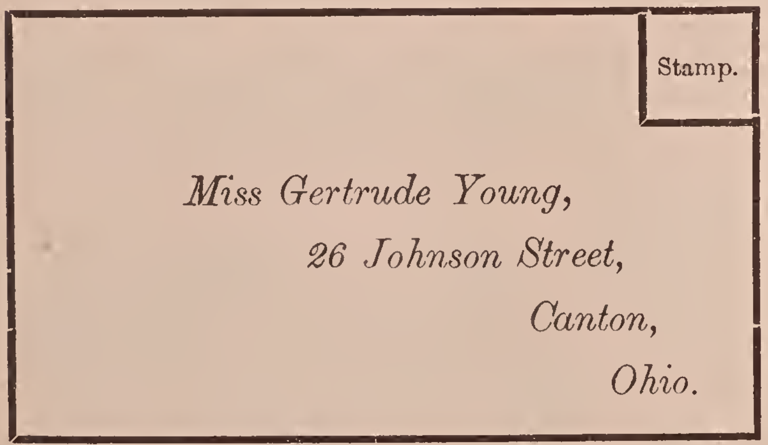
Next is the salutation, which tells to whom the letter is written. The body of the letter then follows and tells what is said. The conclusion is made up of the closing words and the signature of the writer.

Copy the letter to Tom, and be careful to write it just as given, using capitals and marks of punctuation as they are used in that letter.

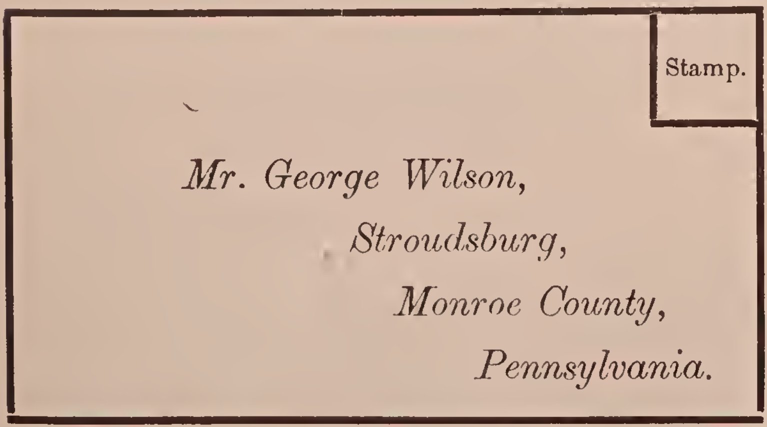
Write a letter to your cousin. Tell her of a trip you made to the park. Begin and close your letter like the model given above, but use the town in which you live, your own name and the name of your cousin.

THE ADDRESS.

The address is made up of the name and residence, as—



Miss Gertrude Young,
26 Johnson Street,
Canton,
Ohio.



Mr. George Wilson,
Stroudsburg,
Monroe County,
Pennsylvania.

When the words street, avenue and county occur in addresses they are sometimes abbreviated, as follows:

Street—St. Avenue—Ave. County—Co.

The name of the state is sometimes abbreviated, but it is better to write all these words in full.

If you were writing your mother's address on an envelope, what would you place before her name? If you were writing your father's address, what would you put before his name?

Draw on paper two envelopes like those at the beginning of this lesson.

Copy in the addresses just as they are given. Use commas and periods as they are used in those addresses. Make the place for postage stamp.

Write your own address as it should be written on an envelope.

Write the address of your father or mother.

Write the addresses of three boys you know.

COMPOSITION.

Write a letter to a friend, and begin and close it like the model.

Exercise 1.

If the weather is nice Charles is going to his father's cottage at the seashore to spend Thanksgiving, and he wants Ralph to go with him. Ralph is to bring some of the provisions and his bicycle. Write the letter for Charles.

Exercise 2.

To-morrow is Ruth's birthday, and she wants May to come to take tea with her and bring her doll.

Write letter for Ruth.

Exercise 3.

May thanks Ruth for the invitation to tea, but says she is going to her Grandma's, so can't come. She sends Ruth a book for her birthday.

Write letter for May.

Exercise 4.

Charles has found his sweet peas are in bloom. He wants Edward to come to see them. He will be home on Saturday. He will give Edward a box of them.

Write letter for Charles.

PRIMARY ARITHMETIC

THE NUMBER TWO.

How many hands have you?
How many eyes have you?
How many feet have you?
How many ears have you?
Show me two pencils, 2 books.
Write the figure **2**.

Show me one block. Put one block with it. How many blocks have you? How many blocks are 1 block and 1 block?

Show me one girl. Show me another. How many girls have you shown me? One girl and one girl are how many girls?

Show me two blocks. Take one away. How many are left?

If I have two horses and sell one horse, how many have I left?

How many are 2 boys less 1 boy?
How many are 2 less 1?

Take one apple. Now take one more.
How many times have you taken one?
How many then are 2 times one apple?
How many are 2 times 1?

If there are two cakes, how many boys can each have one? How many ones in 2?

THE NUMBER THREE.

Show me two blocks. Put one more block with them. How many blocks have you? Show me three blocks.

Write the figure **3**.
How many are 2 boxes and 1 box?
How many are 2 oranges and 1 orange?
How many are 1 pie and 2 pies?
How many are 2 and 1?

If we have 3 boxes and I take one away, how many are left? If I take two, how many are left? If I take three, how many are left?

How many are 3 less 1? 3 less 2? 3 less 3?

If I take one marble, take one more, take one more, how often do I take one?

How many then are 3 times one marble?
How many are 3 times one kite?
How many are 3 times one?

If I have three dolls, how many girls can each have one doll? How many ones in three?

NUMBER FOUR.

Show me three blocks. Show me one block. How many blocks have you altogether?

Show me four boys.
Write the figure **4**.
How many are 3 dogs and 1 dog?
How many are 2 cakes and 2 cakes?
How many are 1 apple and 3 apples?
How many are 3 and 1? 1 and 3? 2 and 2?

Show me 4 balls.
Take 1 ball away. How many are left?
Take 2 balls away. How many are left?
Take 3 balls away. How many are left?
Take 4 balls away. How many are left?
How many are 4 less 1? 4 less 2? 4 less 3? 4 less 4?

If John takes one block at a time for four times, how many blocks will he have?

How many then are 4 times 1 block?
How many are 4 times 1?

If John takes 2 blocks at a time for 2 times, how many blocks will he have?

How many are 2 times 2 blocks?
How many are 2 times 2?

Put 4 blocks in 2 equal piles.
How many blocks in a pile?
How many twos in four?
How many ones in four?

NUMBER FIVE.

Show me four blocks. Put one block with them. How many have you now?

Draw five blocks.

Make the figure **5.**

How many are 4 blocks and 1 block?

How many are 2 hats and 3 hats?

How many are 3 cows and 2 cows?

How many are 4 and 1? 3 and 2?

Show me 5 books.

If I lose one book, how many are left?

If I lose two books, how many are left?

If I lose three books, how many are left?

If I lose four books, how many are left?

If I lose five books, how many are left?

How many then are 5 less 1? 5 less 2? 5 less 3? 5 less 4? 5 less 5?

NUMBER SIX.

Show me five blocks. Show me one more block. How many have you now?

Draw six blocks.

Make the figure **6.**

How many are 5 balls and 1 ball?

How many are 4 horses and 2 horses?

How many are 3 houses and 3 houses?

How many are 5 and 1? 4 and 2? 3 and 3?

The sign + means **and**

The sign = means **are.**

4+2=6 is only another way of writing 4 and 2 are six.

What are 5+1=? 3+3=? 4+2=?

Show me 6 knives.

How many are 6 knives less 1 knife?

How many are 6 horses less 2 horses?

How many are 6 cows less 3 cows?

How many are 6 dogs less 4 dogs?

How many are 6 cats less 5 cats?

How many are 6 chickens less 6 chickens?

Use the sign — in place of **less.**

Write 6—1=5 instead of 6 less 1 are 5.

Put 6 pencils in two equal piles. How many in each pile? How many are 2 times 3 pencils? How many are 2 times 3?

Put them in 3 equal piles. How many in each pile?

How many are 3 times 2 blocks?

How many are 3 times 2? 2 times 3? 6 times 1?

Mary has six dollars. To each of how many girls can she give two?

How many twos in six?

To each of how many girls can she give three.

How many threes in six?

How many ones in six?

NUMBER SEVEN.

How many are 6 blocks and 1 block?

Draw seven blocks.

Write the figure **7.**

How many are 6 boys and 1 boy?

How many are 5 cows and 2 cows?

How many are 4 dogs and 3 dogs?

How many are 5+2=? 4+3=? 6+1=?

How many are 7 oranges less 1 orange?

How many are 7 pens less 2 pens?

How many are 7 tops less 3 tops?

How many are 7 kites less 4 kites?

How many are 7 marbles less 5 marbles?

How many are 7 balls less 6 balls?

How many are 7 pencils less 7 pencils?

How many then are 7—1=? 7—2=? 7—3=? 7—4=? 7—5=? 7—6=? 7—7=?

NUMBER EIGHT.

How many are 7 blocks and 1 block?

Draw eight blocks.

Write the figure **8.**

How many are 7 cats and 1 cat?

How many are 6 books and 2 books?

How many are 5 flags and 3 flags?

How many are 4 tops and 4 tops?

How many are 7+1=? 6+2=? 5 4+4=?

How many are 8 apples less 1 apple?

How many are 8 pears less 2 pears?

How many are 8 peaches less 3 peaches?

How many are 8 oranges less 4 oranges?

How many are 8 cherries less 5 cherries?

How many are 8 bananas less 6 bananas?

How many are 8 cakes less 7 cakes?

How many then are 8—4=? 8—6=? 8—3=? 8—2=? 8—7=?

How many are 4 blocks and 4 blocks?

How many then are 2 times 4 blocks?

How many are 2 times 4 boys?

How many are 2 times 4?

Use the sign × instead of the word times, as 2×4=8.

If one doll costs 2 cents, how many can you get for 8 cents?

If one book costs 4 cents, how many can you get for 8 cents?

How many 4's in 8?

How many 2's in 8?

NUMBER NINE.

If I have eight blocks and take one more, how many have I then?

Draw nine blocks.

Write the figure **9**.

How many are 8 boys and 1 boy?

How many are 5 books and 4 books?

How many are 6 apples and 3 apples?

How many are 7 cows and 2 cows?

How many are 9 birds less 1 bird?

How many are 9 papers less 3 papers?

How many are 9 balls less 2 balls?

How many, then, are 9 less 1? 9 less 2? 9 less 3? 9 less 6? 9 less 8? 9 less 4? 9 less 7?

If I take 3 blocks 3 times, how many blocks have I? How many, then, are 3 times 3 blocks? How many are 3 times 3 horses? How many are 3 times 3?

How many apples can you buy for 9 cents, if you pay 3 cents for each one? How many 3's in 9? or what is 9 divided by 3? Write the sign $\div$ instead of divided by.

THE NUMBER TEN.

9 hats and 1 hat are how many hats?

Write the number **10**.

9 cows and 1 cow are how many?

8 books and 2 books are how many?

7 tops and 3 tops are how many?

6 oranges and 4 oranges are how many?

How many are $9+1$, $8+2$, $7+3$, $6+4$, $5+5$?

If Walter had ten pigeons and one died, how many are left? How many are $10-1$? How many are $10-2$? $10-3$? $10-4$? $10-5$? $10-8$? $10-7$? $10-9$?

If one orange costs 5 cents, what will 2 oranges cost? $2\times5=?$

If one apple costs 2 cents, what will 5 apples cost? $5\times2=?$

If a book costs 5 cents, how many can you get for 10 cents? $10\div5=?$

If a top costs 2 cents, how many can you get for 10 cents? $10\div2=?$

ELEVEN AND TWELVE.

9 boxes and 2 boxes are how many?

Write the number **11**.

8 fans and 4 fans are how many?

Write the number **12**.

7 dolls and 5 dolls are how many?

6 kites and 5 kites are how many?

If I had 11 cents and spent 5 cents, how many would I have left? $11-5=?$

If I had 12 horses and sold 8, how many would I have left? $12-8=?$

If I had 11 cows and 7 died, how many would I have left? $11-7=?$

At 6 cents apiece, how much must I pay for 2 apples? 2×6 cents$=?$

At 3 cents apiece, how much must I pay for 4 books? 4×3 cents$=?$

If 1 slate costs 6 cents, how many can I get for 12 cents? $12\div6=?$

Write the number **20**.

ROMAN NUMERALS.

I=1, V=5, X=10, L=50, C=100, D=500, M=1,000.

Other numbers are expressed by writing side by side two or more of these letters.

If a letter is written after another letter of the same or greater value the sum of these values is expressed thus:

I=1
II=2
X=10
XI=11
X=10
XXX=30
L=50
LX=60

If a letter is written before another letter of greater value, the difference of these values is expressed thus:

V=5
IV=4
X=10
IX= 9
L=50
XL=40
C=100
XC= 90

Roman Numbers to 20.

I=1
II=2
III=3
IV=4
V=5
VI= 6
VII= 7
VIII= 8
IX= 9
X=10
XI=11
XII=12
XIII=13
XIV=14
XV=15
XVI=16
XVII=17
XVIII=18
XIX=19
XX=20

WRITING NUMBERS.

You know that up to nine we use a different character for each number. Numbers greater than nine are expressed by writing two or more of these figures side by side, thus:

10=1 ten called.
11=1 ten and 1 unit.
12=1 ten and 2 units.
And so on to 19.

20=2 tens called twenty.
21=2 tens and 1 unit, called twenty-one.
22=2 tens and 2 units, called twenty-two.
And so on to 29.
In like manner we have 30, 40, 50, 60, etc.

A figure in the third place is called hundreds.
100=1 hundred.
123=1 hundred, 2 tens and 3 units, or one hundred and twenty-three.

For convenience in reading and writing numbers the figures of a number are divided into periods of 3 figures each. The first three figures make the unit period, the second three the thousand period, and the third three places the million period, and so on.

The periods are separated from each other by commas.

Each period, except the last or highest, must have three places.

Example:

millions thousands units
4,325,216. Read 4 millions, 325 thousands, 216.

Read the following:

1	2	3
2,000	25,000	220,000
3,200	32,600	400,000
5,250	29,650	525,200
4,264	18,900	927,850

4	5	6
1,000,000	23,000,000	220,000,000
4,000,000	28,600,000	150,200,000
5,500,000	45,750,000	240,250,000
9,850,000	88,800,000	500,300,245

Write in figures:

1. Two hundred and ten.
2. Four hundred and twenty-five.
3. Nine hundred and eight.
4. Three thousand, two hundred and two.
5. Ten thousand, four hundred and fifteen.
6. Twenty thousand five hundred.
7. Eight hundred and twenty thousand.
8. Twenty-six millions.
9. Thirty-four millions, two hundred and five thousands.
10. One hundred and ten millions, two hundred thousands, four hundred and forty-four units.

MULTIPLICATION TABLE.

2× 1= 2	3× 1= 3	4× 1= 4
2× 2= 4	3× 2= 6	4× 2= 8
2× 3= 6	3× 3= 9	4× 3=12
2× 4= 8	3× 4=12	4× 4=16
2× 5=10	3× 5=15	4× 5=20
2× 6=12	3× 6=18	4× 6=24
2× 7=14	3× 7=21	4× 7=28
2× 8=16	3× 8=24	4× 8=32
2× 9=18	3× 9=27	4× 9=36
2×10=20	3×10=30	4×10=40
5× 1= 5	6× 1= 6	7× 1= 7
5× 2=10	6× 2=12	7× 2=14
5× 3=15	6× 3=18	7× 3=21
5× 4=20	6× 4=24	7× 4=28
5× 5=25	6× 5=30	7× 5=35
5× 6=30	6× 6=36	7× 6=42
5× 7=35	6× 7=42	7× 7=49
5× 8=40	6× 8=48	7× 8=56
5× 9=45	6× 9=54	7× 9=63
5×10=50	6×10=60	7×10=70
8× 1= 8	9× 1= 9	10× 1= 10
8× 2=16	9× 2=18	10× 2= 20
8× 3=24	9× 3=27	10× 3= 30
8× 4=32	9× 4=36	10× 4= 40
8× 5=40	9× 5=45	10× 5= 50
8× 6=48	9× 6=54	10× 6= 60
8× 7=56	9× 7=63	10× 7= 70
8× 8=64	9× 8=72	10× 8= 80
8× 9=72	9× 9=81	10× 9= 90
8×10=80	9×10=90	10×10=100

ADDITION.

1. A farmer had 7 sheep and bought 4 more; how many did he then have?
2. Charles had 8 cents and his mother gave him 7 more; how many had he then?
3. Ralph is 9 years old and his brother is 5 years older; how old is his brother?
4. If Willie paid 5 cents for a pound of sugar and 9 cents for beans, how much did he pay for both?
5. Thomas has 7 apples, Brant 5 and Louis 8; how many do they together have?

4+5=9	7+5=12	8+3=11	4+2+2=8.
4	7	8	4
5	5	3	2
—	—	—	2
9	12	11	—
			8

These are just two ways of writing the same thing.

Now, suppose we have larger numbers to add, as 124+253=?

Case I.

If the sum of no column is more than 9:

We write the numbers so that units shall form the first column, tens the second and hundreds the third.

124
253
377 Ans.

Begin at units to add, naming results only, as 4, 7. Write 7 in units column. Then add tens, 2, 7. Write 7 in tens column. Then add hundreds, as 1, 3. Write 3 in hundred column. Ans., 377.

Case II.

If the sum of a column is more than 9:

(1.) 251
427
134
812

Write as before.

Add numbers, naming results only, as 1, 8, 12 or 12 units, or 1 ten and 2 units. Write the units in the units column and add the 1 ten to the column of tens.

The sum of 1 ten, 5 tens, 2 tens, 3 tens is 11 tens, or 1 hundred and 1 ten. Write the 1 ten in the tens column, and add the 1 hundred to the column of hundreds. 1 hundred, and 1 hundred and 4 hundreds and 2 hundreds is 8 hundreds. Put in the hundreds column. Ans., 812.

(2.) Find the sum of 483, 926, 174.

483
926
174
1,583 Ans.

In practice we name only results in adding. Thus, 3, 9, 13. Write 3 and carry one to next column. Then 1, 9, 11, 18. Write 8 and carry 1 to next column.

Then 1, 5, 14, 15. Write 15 in last column.

1. John is twelve years, Brant is nine, and George is seven years old. What is the sum of their ages?

2. A horse cost 125 dollars, a carriage 75 dollars, and a harness 25 dollars. What did they all cost?

3. Charles rode 15 miles one day, 23 miles the next day, and 12 miles the third day. How far did he ride in the three days?

SUBTRACTION.

Case I.

To subtract when no term of the subtrahend is greater than the corresponding term of the minuend.

Subtract 46 from 89.

Minuend 89
Subtrahend 46
43

We write the less under the greater, with units under units, tens under tens, etc.

6 units from 9 units leaves 3 units, which we write under the units.

4 tens from 8 tens is 4 tens, which we write under the tens. Ans., 43.

Case II.

To subtract when a term in the subtrahend is greater than the corresponding term in the minuend.

1. Subtract 256 from 483.

Minuend 483
Subtrahend 256
227

Since we cannot take 6 units from 3 units, we add 10 units to 3 units, making 13 units. 6 units from 13 units leaves 7 units, which we place in units column. To balance the 10 units added to the units column, we take 1 ten from the tens column, leaving it 7 tens. 5 tens from 7 tens leaves 2 tens. 2 hundreds from 4 hundreds leaves 2 hundreds.

2. Subtract 246 from 425.

Minuend 425
Subtrahend 246
179

In practice it is customary to say:

6 from 15 leaves 9.
4 from 11 leaves 7.
2 from 3 leaves 1.

3.	343 185	4.	4,000 2,591	5.	507 263
6.	8,003 4,529	7.	4,321 167	8.	10,352 9,468

1. Mary had 57 cents and spent 28 cents. How many had she left?

2. If Guy had 425 marbles and gave away 347 marbles, how many had he left?

3. If a horse was bought for $325 and sold for $287, what was the loss?

4. If a man had 187 chickens and 59 died, how many had he left?

5. How many years is it since Columbus discovered America in 1492?

6. If Ralph had $10,000 in bank and drew out $5,387, how much had he still in bank?

7. If a boy bought a book for 25 cents, a slate for 10 cents, and a tablet for 7 cents, how much had he left out of a dollar?

MULTIPLICATION.

Case I.

When the Multiplier is One Figure.

1. Addition.

123
123
123
369

We see in this addition that the same number is taken three times. So time is saved if we write the number once and the number of times it is taken under it. Then it is called multiplication.

123
3
369

Multiplication is a short form of addition.

2. Multiply 215 by 5.

Multiplicand 215
Multiplier 5
Answer 1,075

We write the multiplier under the units figure of the multiplicand and begin at the right to multiply.

5 times 5 units is 25 units, or 2 tens and 5 units. We write the 5 units in the units column and add 2 tens to the next product.

5 times 1 ten is 5 tens, plus 2 tens, is 7 tens, which we write in the tens column.

5 times 2 hundred is 10 hundreds, which we write in the hundreds column.

3. Multiply

423
9
3,807

It is customary in practice to say 9 times 3 are 27. Write 7 and carry 2. 9 times 2 are 18 and 2 are 20. Write 0 and carry 2. 9 times 4 are 36 and 2 are 38.

Case II.

When the Multiplier Consists of Two or More Figures.

1. Multiply 427 by 59.

Multiplicand 427
Multiplier 59
3843
2135
25193

In this problem we must multiply 427 by 9 units and 5 tens. 9 times 427 is 3,843. 5 times 427 is 2,135, and since the multiple is tens the product is tens. Add the partial products and we have 25,193.

2. 6,087 × 602
3. 46,721 × 367
4. 15,409 × 516
5. 5,432 × 45
6. 73,002 × 906
7. 18,095 × 739

8. If a pound of coffee costs 27 cents, what will 423 pounds cost?

9. If one horse costs $210, what will 115 horses cost?

10. If a family used 35 loaves of bread in a week, how many will they use in 42 weeks?

11. At 60 cents a bushel, what will 120 bushels of wheat cost?

12. A farmer bought 12 cows at 25 dollars each, 20 pigs at 8 dollars, and 5 horses at 120 dollars each. What did he pay for them all?

SHORT DIVISION.

1. Divide 246 by 2.

Dividend
Divisor 2)246
Quotient 123

2 is contained into 2, 1 time.
2 is contained into 4, 2 times.
2 is contained into 6, 3 times.

This process is called short division.

2. Divide 724 by 4.

Process:

Dividend
Divisor 4)724(181 Quotient
4
32
32
4

4 is contained in 7 hundreds 1 hundred times, with 3 hundreds remaining. 3 hundreds equal 30 tens, which, with the 2 tens, make 32 tens. 4 is contained in 32 tens 8 tens times. 4 is contained in 4 one time.

Process in practice:

Dividend
Divisor 4)724(181 Quotient
4
32
32
4

In practice we say 4 is contained in 7, 1 time with 3 remaining. 4 is contained in 32, 8 times. 4 is contained in 4 one time.

1. Divide 412 by 4; by 3; by 2.
2. Divide 625 by 4; by 2; by 3.
3. Divide 10,215 by 5; by 7; by 9.
4. Divide 82,423 by 7; by 8; by 9.
5. Divide 71,236 by 8; by 9; by 7.

1. At 5 cents apiece, how many oranges can be bought for 425 cents?

2. At 4 cents apiece, how many pieces of soap can you get for 124 cents?

3. If a boy averages 7 miles an hour on his bicycle, how long will it take him to travel 105 miles?

4. At $6 a ton, how many tons of coal can be bought for $312?

5. If a drover paid $927 for a drove of sheep, and each sheep cost $9, how many sheep in the drove?

LONG DIVISION.

Divide 35,647 by 43.

Process:

```
43)35647(829
   344
   ---
    124
     86
    ---
     387
     387
     ---
```

43 is contained in 356, 8 times with a remainder of 12. Bringing down the next figure, we have 124. 43 is contained in 124, 2 times with a remainder of 38. Bringing down the next figure, we have 387. 43 is contained in 387, 9 times with no remainder. So the quotient is 829.

This process is called long division.

Proof. 829, the quotient, multiplied by 43, the divisor, equals 35,647, the dividend. Hence, the work is correct.

Divide:

1.— 441 by 21.
2.—3,108 by 28.
3.— 450 by 18.
4.—2,343 by 33.
5.— 391 by 17.
6.— 64,056 by 49.
7.— 24,244 by 56.
8.— 42,777 by 63.
9.—104,832 by 72.
10.— 24,192 by 56.

Divide 64,355 by 211.

Process:

```
211)64355(305
    633
    ----
     1055
     1055
     ----
```

If a remainder, with the next figure of the dividend annexed, does not contain the divisor, place a cipher in the quotient and bring down another figure of the dividend.

1. If one acre of land costs $31, how many acres can you get for $6,510?

2. If a hogshead contains 63 gallons, how many hogsheads can be filled from 89,208 gallons?

3. If one cow costs $27, how many can you get for $2,592?

4. There are 36 inches in a yard. How many yards in 29,700 inches.

5. A merchant paid his 19 salesmen $2,128. How much did each receive?

MISCELLANEOUS EXAMPLES.

1. A child's pulse beats 78 times in a minute; how often does it beat in an hour (60 minutes)?

2 John has $3,250 and Charles has 3 times as much. How much has Charles?

3. B paid $15 for 5 barrels of apples. What will 7 barrels cost at the same rate?

4. The dividend is 3,250, and the divisor is 65. What is the quotient?

5. If 9 sheep cost $63, what will 5 sheep cost at the same price?

6. The divisor is 29 and the quotient 43. What is the dividend?

7. If Mr. White raised 336 bushels of wheat on 12 acres, what was the average yield per acre?

8. If I bought a farm of 65 acres for $1,300, what did I pay per acre?

9. Frank has $28, Guy $43, and Charles $72. How many have they all?

10. The population of New York City is 3,437,202 and that of Chicago is 1,698,575. How much greater is the population of New York than that of Chicago?

11. A quire of paper has 24 sheets. How many quires in 1968 sheets?

12. What number multiplied by 12 will give 2,160?

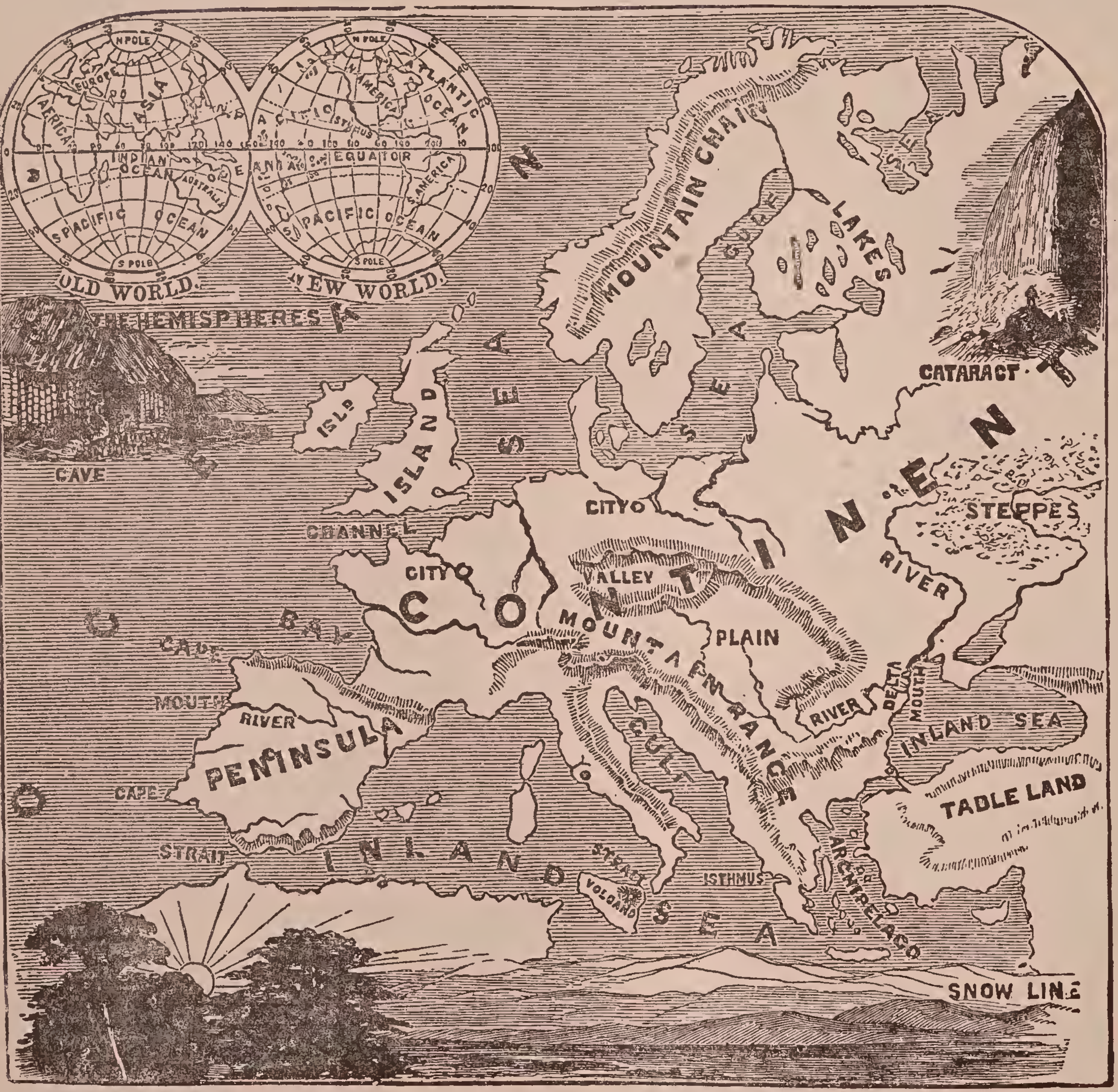
13. A merchant sold 7 pieces of cloth, each containing 30 yards, for $1.25 a yard. How much did he receive for it?

14. Brant has 3 dimes and one cent. How many pencils, at 4 cents apiece, can he buy with his money, and how many cents will he have left?

15. In one class in our school there are 12 boys and 13 girls, in another 18 boys and 17 girls, and in another 21 boys and 23 girls. How many boys are there in all? How many girls? How many children?

16. If I buy a book for 25 cents, a box of candy for 28 cents, a picture for 35 cents and a game for 42 cents, what will they all cost me?

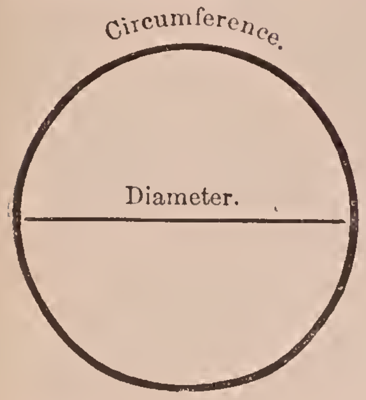
STORY OF OUR EARTH—GEOGRAPHY



PRINCIPAL DIVISIONS OF LAND AND WATER.

Geography tells about the earth and its people. The **Earth,** or, as some say, the **Globe** or the **World,** is round like an orange. An orange is flattened a little where the stem was, and at the other side where the flower was. So the earth is flattened a little at two opposite points, called its poles. One pole is called the **North Pole,** the other the **South Pole.**

The distance round the earth is called its **Circumference.** This distance or circumference is about 25,000 miles.



The distance through the middle of the earth is called the **Diameter.** This distance, or diameter, is about 8,000 miles.

The surface of the earth is made up of **land** and **water.** The **water** surface is about three times as large as the land surface; or, you may say that the land forms one-fourth of the earth's surface, and the sea three-fourths.

FORMS OF LAND.

The largest piece of land is called a **Continent.** There are three **Continents** on the earth—the **Eastern,** the **Western,** and the **Australasian** (os-tral-a′shan). Sometimes in speaking of large pieces of land, or continents, we say there are six—Asia, Africa, North America, South America, Europe and Australia.

The edge of a body of land where the water joins it is called a **Coast.**

A **Peninsula** (pe-nin′su-la) means almost an island. It is that part of a mainland which reaches out at some length into the water. It would be an island but for the fact that it is joined by a narrow strip to the mainland.

An **Isthmus** is the narrow strip of land which joins a peninsula to the mainland.

A **Cape** is a point or piece of land which extends somewhat sharply out into the sea. When the point of a cape is high and rocky it is called a **Promontory.** This word means a headland or high coast.

An **Island** is a piece of land cut off altogether from a continent and entirely surrounded by water.

Islands are often found in groups or clusters. A cluster of islands is called an **Archipelago** (ar′ki-pel′a-go).

A **Reef** is a chain of rocks lying near the surface of the water. Reefs are very dangerous to ships.

A **Plain** is a large, flat or level piece of land. It need not be altogether level, but may be of a gently rolling or wavy surface. When a **Plain** is a broad, high-up piece of land it is called a **Plateau** (pla-to′) or a **Table-land.**

A **Desert** is a dry, sandy, barren piece of land, sometimes of great extent. A fertile spot in the midst of a desert is called an **Oasis** (o′-a-sis).

A **Mountain** is raised or elevated land, being much higher than the land around it.

When many mountains come close together they make what is called a **Mountain Range,** or **Chain** of mountains.

When mountains are small they are called **Hills.** Small hills are called **Hillocks.**

A **Volcano** (vol-ka′no) is a mountain which throws out melted rock (lava), steam and gases. The opening through which these substances are thrown is called a **Crater.**

A **Valley** is a tract of land lying between two mountains, or chains of mountains. When such valley is narrow and with steep, rocky sides it is called a **Canon** (kan′yon).

OCEAN WATERS.

The **Ocean** is the largest body of water on the surface of the earth. It is sometimes called the **Sea.** There are five **Oceans**—the **Atlantic, Pacific, Indian, Arctic** or **Northern, Antarctic** or **Southern.**

When the water of the ocean extends very far into the land and becomes large, it is called a **Gulf.**

When it does not extend inland so far, and is not so large a body, it is called a **Bay.**

When an inlet of water from the ocean is not very deep it is called a **Sound.**

A **Strait** is a narrow neck or passageway of water joining two large bodies of water. When a **Strait** is very wide and long, it is called a **Channel.**

The surface of the ocean is always in motion. The up and down motions caused by the wind are called **Waves. Tidal Waves** are immense waves that roll in upon the land.

Tides are the daily rising and falling of the ocean, caused by the turning of the earth and the attraction of the sun and moon.

Lagoons are parts of the ocean that have been cut off and surrounded by shifting sands or coral reefs.

A **Harbor** is a bay, or smaller body of water, that is sheltered by the land.

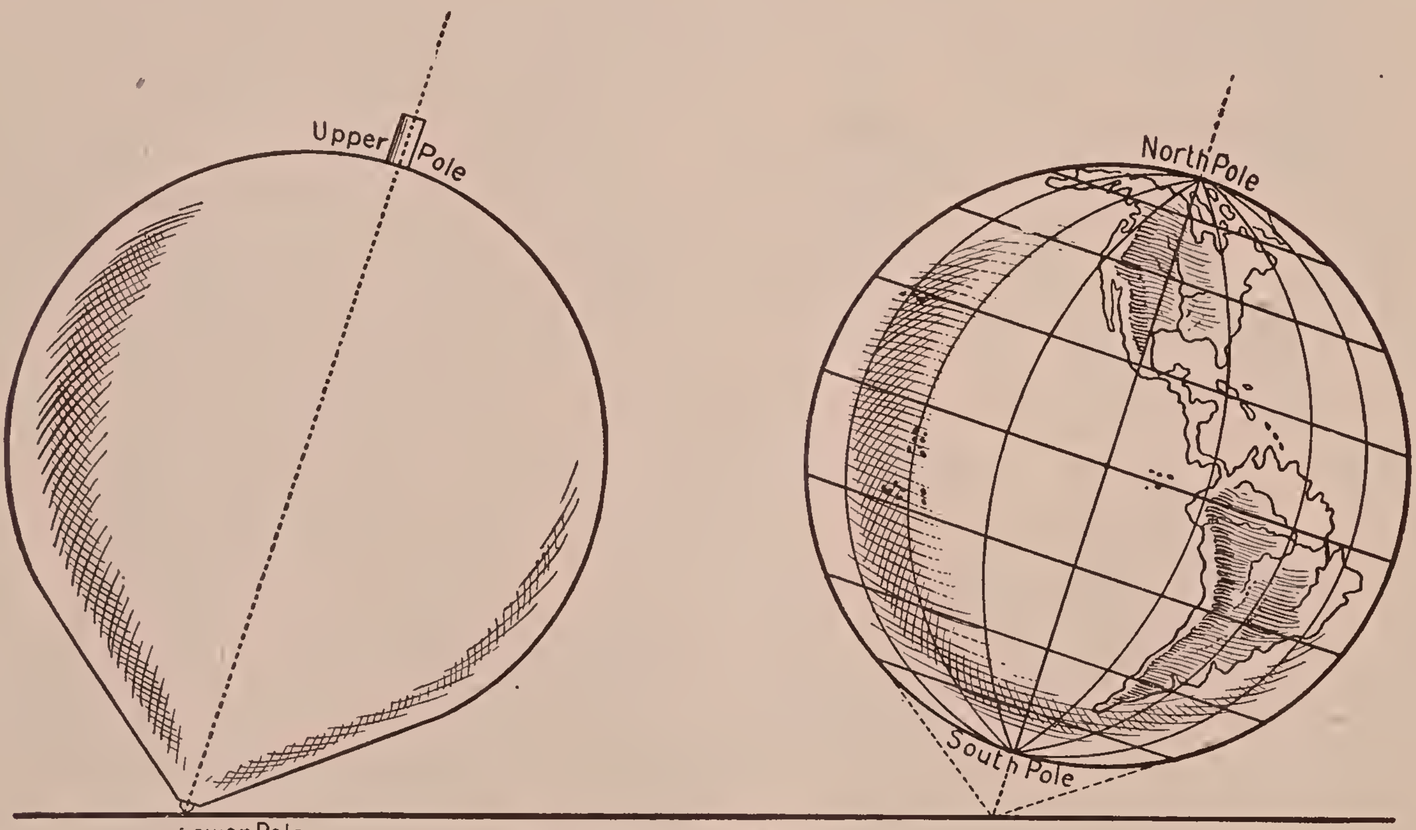
Ocean Currents.—Strange as it may seem, there are great streams like rivers flowing in the ocean.

One of these, called the **Equatorial Current,** flows constantly westward near the Equator. Another, called the **Gulf Stream,** flows northward in the Atlantic Ocean, from the Gulf of Mexico. Another, called the **Japan Current,** flows westward in the Pacific Ocean toward the coast of Japan. The waters of these **Currents** are generally warmer than those around them.

INLAND WATERS.

Ocean waters are salty. Inland waters are, as a rule, fresh.

A **Lake** is a large body of water contained in a hollow place in the earth's surface. Its waters are supplied by streams running into it. Some few lakes are salty; some are very large, others are small. A small, shallow lake is sometimes called a **Pond.**



ROTATION OF THE EARTH.

A **River** is a large stream of water flowing along a bed or channel.

The **Source** of a river is the place or spring from which it begins to flow.

A little stream flowing out of a bank or side-hill is called a **Spring.**

Waters running away from a spring, or from many springs, are called **Rivulets** or **Brooks.**

Streams of water helping to form a river, or flowing into a river already formed, are called its **Tributaries, Feeders** or **Branches.**

The **Mouth** of a river is the place where its waters enter into another body of water. The body of land formed at the mouth of a river by the earth which it brings down is called a **Delta.**

The **Bed** of a river is the bottom of the channel in which it flows. **Up-stream** is toward a river's source; **Down-stream** is toward its mouth.

The **Right-bank** of a river is the bank on your right-hand when you are looking down-stream. When looking in the same direction, the **Left-bank** is on your left.

The **Basin** of a river is the land through which its waters and those of its branches flow.

A **Waterfall** or **Cataract** is the steep drop of the waters of a river from a high level to a lower one.

Rapids are the gradual or slanting drop of the waters of a river from a higher to a lower level.

A **Glacier** (gla′sher) is a large field or stream of ice which moves slowly down a mountain slope into a valley or ocean. When the lower part of a glacier breaks off and drops into the ocean, it becomes an **iceberg.**

An **Avalanche** (av′a-lanch) is a great mass of snow and ice sliding swiftly down a mountain side.

A Geyser (gi′ser) is a hot spring that pours its water high in the air, and sometimes with great violence.

MOTIONS OF THE EARTH.

Daily Motion.—The earth spins round, or rotates, like a top. Look at the picture of the top, and think of it as spinning to the right. The top has a spindle. Its point is one end of the spindle. If the spindle were extended through the top, its other end would be on the upper side of the top. In the place of this spindle, we must think of a line down through the centre of the earth. Of course, there is no such line, but we must imagine it. Such an imaginary line is called an **axis**, or the line around which an orb turns. All planets have an axis on which they turn or rotate.

Poles.—The ends of the earth's axis are called its **poles**. One of these poles is called the **North-pole** and the other the **South-pole**. The top leans a little as it spins. The earth leans like the top as it spins, only it does not need to rest on anything. It is held in its place by a law called **gravity**, that is, it is held in its course around the sun pretty much as if it were attached to the sun by a strong cord.

Rotation or Turning.—It takes the earth 24 hours to rotate, or turn, once on its axis. We, on the surface of the earth, go with it as it turns, for we are held to the earth by its attraction. Therefore, a person living on the equator, or midway between the poles, would travel in a day, 25,000 miles, or about 1,000 miles an hour, but if he stood at the poles he would not move any distance at all.

Day and Night.—We say that one rotation of the earth on its axis gives us one day of 24 hours. That is true, but during a portion of this day the sun is shining upon us, making things light. This is called the time of daylight, or daytime, or **day**. This day is not the day of 24 hours, which we mean when we speak of a single rotation of the earth on its axis. Another portion of the time of the earth's rotation, the sun does not shine upon us, because we are on the side of the earth which is away from, or opposite to, the sun. This time is called **night**. As the earth turns, some of its surface is all the time coming into light, and some passing into darkness. When, in passing around with the earth, we first see the sun, it is **morning** or **sunrise**. When the sun appears to be over our heads, it is **noon**. When we are just being carried into darkness, we say it is **sunset**.

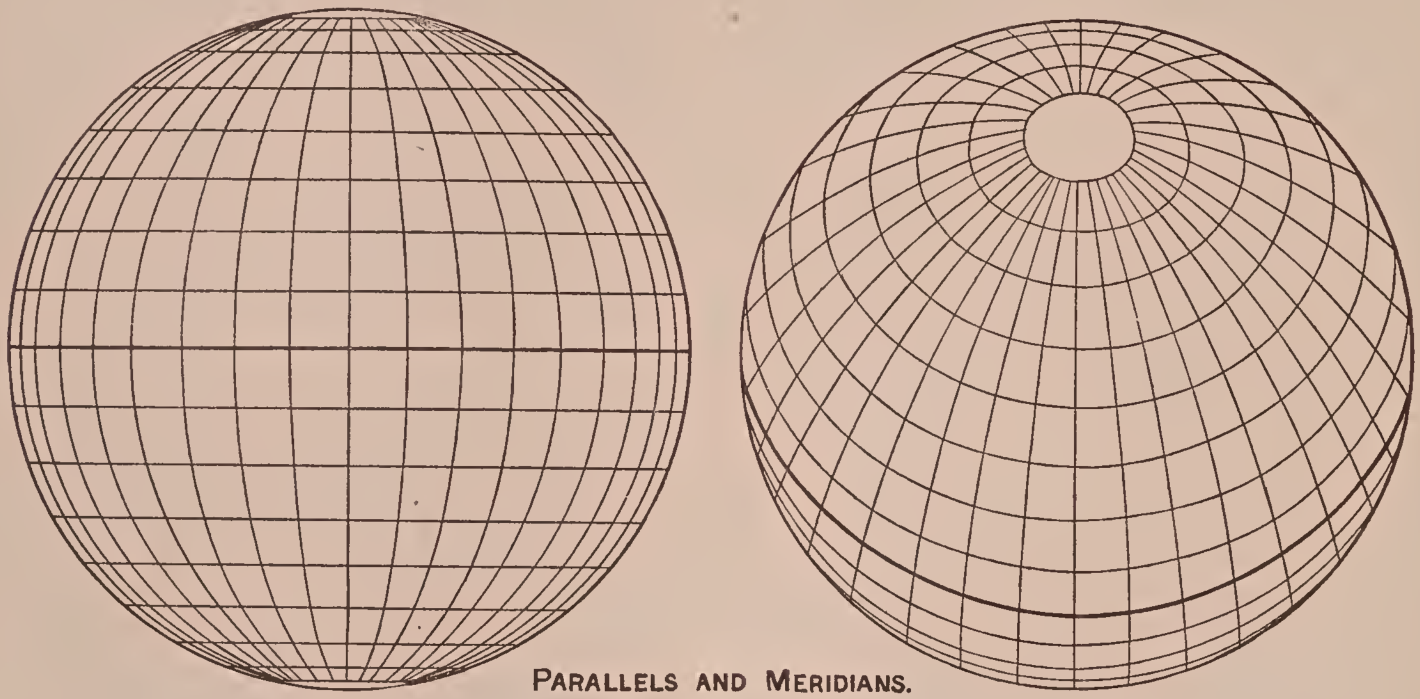
Direction.—When school closes and the scholars go different ways home, you say that they go in different directions. On the earth there are four **main directions**. That toward the North-pole is called **North**. That toward the South-pole is called **South**. If you stand with your face toward the North, your right hand will be in the direction of the **East**, and your left hand in the direction of the **West**. The earth turns on its axis toward the East. We speak of the sun rising in the East, but the sun does not rise at all. It only appears to rise. Sunrise is really the turning of the earth which brings us in sight of the sun. So, sunset is merely the turning of the earth carrying us out of sight of the sun.

Yearly Motions of Earth.—While the earth rotates on its axis, giving us its day of 24 hours long, it is also rushing along in its orbit, or great journey around the sun. This motion of the earth gives us our **year**, which is 365¼ days long; that is, the earth rotates on its axis 365¼ times while it is going once around the sun in its orbit. Orbit means the path of a planet around the sun.

The earth does not face the sun directly, but its axis leans a little, as you have seen in the picture. For this reason the part of the earth we live on is sometimes turned toward the sun and sometimes away from it. When the earth comes to that point in its orbit where the sunlight strikes the part we live in most squarely, it makes the weather warm, and we call it **summer**. As the earth passes on, it comes to another point where the sunlight strikes the part we live in less squarely, then the weather becomes cooler, and we call it **autumn** or **fall**. In going around the sun further the earth reaches a point where the sunlight strikes the part we live in very slantingly. The weather then becomes quite cold, and we call it **winter**. In going around still further the earth comes to a point where the sunlight strikes the part we live in less slantingly than in winter and the weather begins to get warmer. This is called **spring**. Thus the yearly motion of the earth around the sun, and the peculiar lean in its axis produce the four **seasons**.

MAPS OF THE EARTH.

In order that we may find out where we live upon the earth and where other people live, also about distances and directions, we make maps or pictures of its surface. A **map** is, therefore, a representation of the earth's surface, in whole or in part, by means of signs or lines drawn on paper. Some maps are colored, others are not. A **globe** is a ball or sphere covered by a map. On every map you will see lines which run up and down the page over it. These lines show you the direction north or south of any place on the earth's surface. They are called **meridians.** Meridians, on a map or globe, are lines drawn at certain distances apart due north and south, or in the direction of the poles. As you see from the picture, they all pass through the poles of the earth, and at right angles to that great circle drawn around the earth half-way between the poles, which great circle we call the **equator.** Again, you see in the picture lines running directly across the north and south lines. These lines show the direction east and west on any map. They are called **parallels,** because they pass around the earth parallel to the **equator.**



PARALLELS AND MERIDIANS.

Circles.—All the above will become plainer when we say that on our globe or earth are drawn many imaginary circles for the purpose of showing directions and distances, and locating exactly any part or spot we may wish to study. These circles are given names.

A **Great Circle** divides the earth into two equal parts. Each of these parts is called a **hemisphere,** or half a sphere or globe. A great circle corresponds to the circumference of a sphere or globe.

The **Equator** is the imaginary great circle passing around the middle of the earth where its circumference is greatest. Every point in the equator is equally distant from the poles.

A **Small Circle** divides the earth into unequal parts. It is called a small circle because it is smaller than the equator or any great circle.

The **Tropic of Cancer** is the small circle passing around the earth at a distance of 23½ degrees north of the equator.

The **Tropic of Capricorn** is the small circle passing around the earth at a distance of 23½ degrees south of the equator.

The **Arctic Circle** is the small circle passing around the earth at a distance of 23½ degrees from the North-pole.

The **Antarctic Circle** is the small circle passing around the earth at a distance of 23½ degrees from the South-pole.

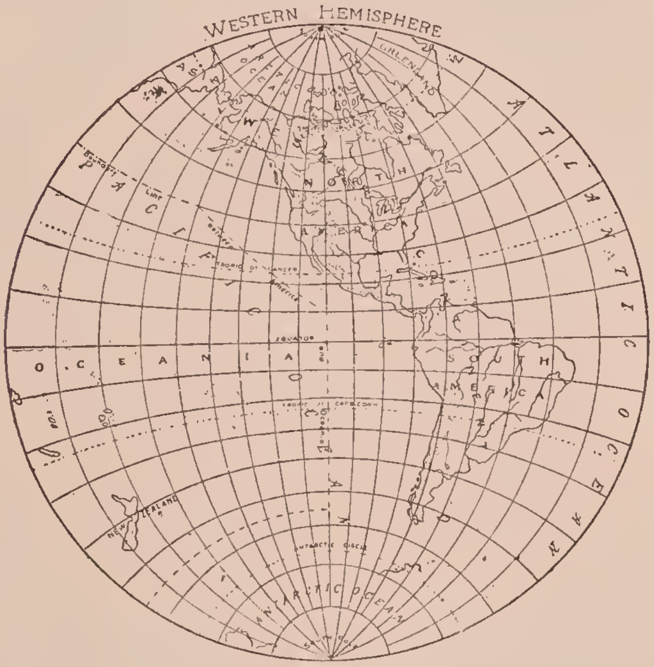
Parallels, as we have seen above, are small circles passing around the earth parallel to the equator.

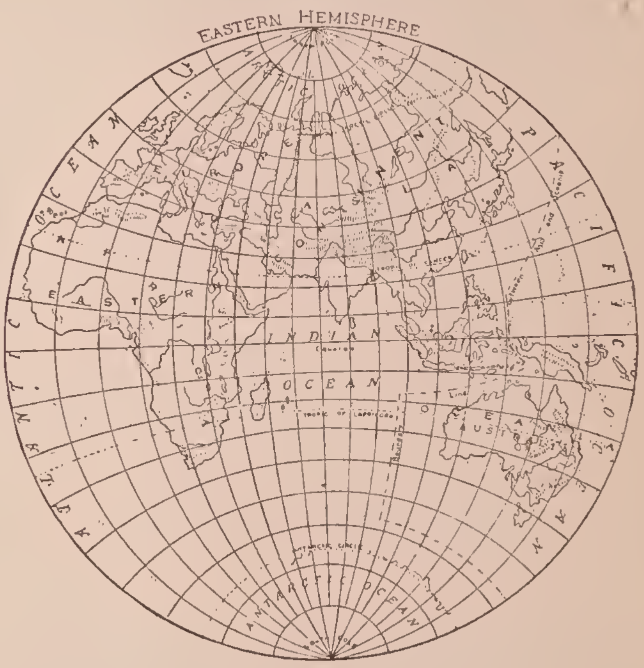
Meridians, as we have also seen above, are small circles passing through the poles at right angles to the equator; that is, they cut squarely across the equator. All these circles are not real, but imaginary.

Hemispheres.—The word **hemisphere** means half a sphere or globe. If we draw in our minds, or with a pencil upon paper, a great circle around the earth, the parts on either side of the circle will be half-spheres, or hemispheres, and each of the same size.

Northern and Southern Hemispheres.—Taking the equator as the great circle which exactly divides the earth into two parts, we call the part that lies north of it the **Northern Hemisphere,** and the part of it that lies south of it the **Southern Hemisphere.** Those who live in the United States live in the Northern Hemisphere.

Eastern and Western Hemispheres.—By drawing a great circle around the earth in a north and south direction, or through the poles, we again divide its surface into two equal parts, or hemispheres. One of these we call the **Eastern Hemisphere,** the other the **Western Hemisphere.** If you look at the picture you will see that the Eastern Hemisphere has far more land in it than the Western; and the Western has far more water in it than the Eastern. The greater part of the land of each is found in the northern portions, and the greater amount of water of each is found in the southern portions.





Latitude.—Latitude means distance north or south of the equator. When we are south of the equator we are in **south latitude.** When we are north of the equator we are in **north latitude.** But if we wish to find out just how far we are north or south of the equator, we must refer to the picture already seen, which shows the lines running east and west around the earth and parallel to the equator—those lines which we have called **parallels.** As seen on a map these lines are usually drawn 10 degrees apart. Therefore, if you are standing on the first one north of the equator you are in North latitude 10 degrees, or 10 degrees north latitude. If you are standing on the second line north of the equator you would be in 20 degrees north latitude, and so on. The same measurements apply to south latitude. One degree is about 70 miles. Ten degrees would, therefore, be 700 miles. If you are standing at 10 degrees north or south latitude, you would be 700 miles north or south of the equator.

Longitude.—Longitude is length or distance east or west from some agreed upon meridian. We have already learned what a meridian is. The meridian which has been agreed upon as the one from which to measure distance east or west around the world is the one which passes through the Greenwich observatory, near London, England. When we are west of that meridian, we are in **west longitude**; when east of it we are in **east longitude.** Like the lines or circles which measure latitude, those which measure longitude appear on maps at 10 degree intervals, so that each degree would be about 70 miles, and 10 degrees would be 700 miles, and so on.

ZONES.

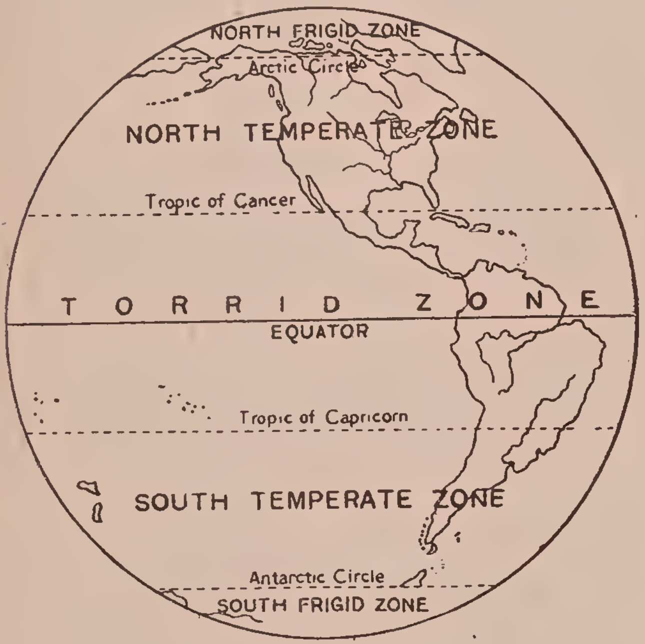
Warmth.—The earth is warmed by the sun's rays. This warmth depends on the way, or direction, in which the sun's rays strike its surface.

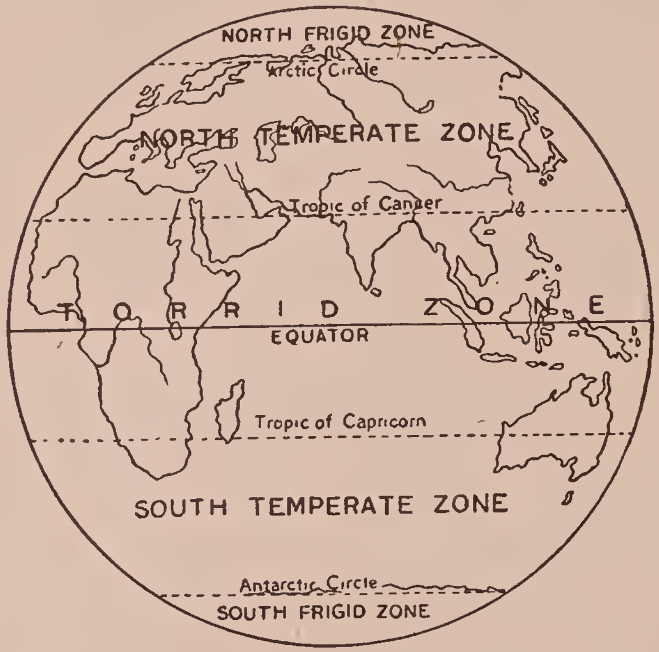
Vertical, or straight down, rays give to earth the greatest heat. Slanting rays give less heat. Consequently the warmest part of the day is at noon, when the sun is directly overhead and his rays strike the earth vertically, or nearly so.

Sun Rays.—The way, or direction, in which the sun's rays strike the earth depends upon the inclination, or lean, of its axis. In our summer, or warmest season, the sun's rays strike the earth most vertically, or straight; and in winter, our coldest season, they strike slantingly, or least vertically. Places along the equator have summer all the time.

Polar Warmth.—When the North-pole is turned toward the sun (it is never more than partly so turned) the sun's rays strike the northern hemisphere more directly than the southern, hence at that time the northern parts of the earth are warmer than the southern parts. When the South-pole is turned toward the sun, then directly the opposite effects are produced. The farther north or south from the equator we go the less heat we meet with, because the sun's rays are striking the earth at a greater slant. Consequently it is very warm at the equator, and very cold at the poles, while in between it is not so hot nor so cold.

Belts or Zones.—We speak of the earth as divided into belts or zones, according as it is hot or cold. These belts or zones are laid out, or marked by imaginary circles or lines which we have already read about in speaking of circles. That belt of earth which lies on both sides of the equator between the Tropic of Cancer and the Tropic of Capricorn is called the **Torrid Zone.** Torrid means hot or warm. That belt or part of the earth which lies between the Tropic of Cancer and the Arctic Circle is called the **North Temperate Zone.** In this belt the weather is neither very hot nor very cold. We live in the North Temperate Zone. That part of the earth's belt which lies between the Arctic Circle and the North-pole is called the **North Frigid Zone.** Frigid means very icy and cold. Turning now to the south side of the equator, the belt between the Tropic of Capricorn and the Antarctic Circle is called the **South Temperate Zone,** because the weather is neither very hot nor cold. Going farther south, that belt of the earth which lies between the Antarctic circle and the South-pole is called the **South Frigid Zone.** The zones do not have an even degree of heat all over them. The edge toward the equator is warmer than the edge that is farthest from it.





RAINFALL.

The heat of the sun turns large quantities of water into a vapor, or fog, which rises up and mixes with the air (atmosphere). The amount of vapor which rises and mixes with the air depends on its warmth (temperature). Warm air will take up and hold more vapor than cold air.

When the air can take up no more vapor or moisture, it is said to have reached the **dewpoint.**

When the air becomes slightly chilled below the dewpoint, moisture is deposited upon objects. This moisture is called **dew.**

When the air is cooled rapidly below the dew-point, the moisture in the clouds falls in the form of drops called **Rain**. In some parts of the earth it rains nearly all the time, in others scarcely any rain falls. Moisture is carried from place to place in the air in the form of **clouds**, which are hurried along by the winds.

WINDS.

Wind is air in motion. This motion is caused by the air being warmer in one place than in another. Thus, the cold air of the poles flows toward the warm air near the equator. In doing so it raises the light, warm air near the equator, which then flows in a higher current back toward the poles.

Trade Winds are constant currents of air, which flow from the poles toward the equator. The turning around of the earth on its axis changes the direction of these currents, and instead of flowing straight from the poles toward the equator they seem to come from the northeast in the northern hemisphere, and from the southeast in the southern hemisphere.

Monsoons.—These are winds which blow six months in one direction and six months in an opposite direction. They belong to the western and southern seas and coasts. At the time they change their direction heavy storms occur.

Variable Winds.—These are such winds as we meet with every day around our homes. We call them **breezes** when they blow gently. They may vary, or change their courses, several times a day.

Land and Sea Breezes.—These are winds which blow from the sea toward the land during the day, and from the land toward the sea during the night.

CLIMATE.

Climate means the air conditions of a place or section, and such conditions are due to the heat and cold, to moisture, to winds, etc. The distance one is north or south of the equator; that is, the **latitude** one is in, modifies or changes the climate.

Climate is also affected or changed by the slant of the sun's rays as they strike the earth; the more slanting they strike the colder it is; the more directly they strike the warmer it is.

Ocean currents, the distance from the ocean, the height above the ocean, the presence of mountains, all these make changes in the air, and, therefore, affect climate.

Mountains, when facing warm waters, turn the moisture passing over them into rain, which falls on the ocean side of the mountains, and the wind passes over cold and dry into the slopes beyond.

Ocean Currents warm the winds and thus give heat and moisture to the nearby lands. This is also true of great lakes and other large bodies of water.

VEGETABLE LIFE.

All vegetable life—trees, grass, plants, flowers—is governed by heat and cold; therefore, such life varies as the climate varies. In the arctic, or cold, zone hardly anything besides mosses grow.

The Great Slopes of the earth grow a variety of vegetable life, because, for the most part, the soil and climate are both kind.

The Tropical Zone, or belt, is the richest in vegetation. Fruits and flowers are constantly growing, and the trees bear leaves all the year round.

The Temperate Belts, or zones, produce most of the grains and grasses of the world. Since rice requires much moisture and warmth, it grows best on low lands where it can be watered, and where it can get the proper heat. It is said to be the food of nearly one-half of the people of the earth. Wheat stands next as a food. Rye, oats and barley grow in colder parts than wheat. Maize, or Indian corn, grows in both the temperate and tropical zones of the entire world.

Strange to say, the Antarctic zone does not produce any vegetation, either on land or in the sea.

THE HUMAN RACE.

The people who live in the world are said to number 1,500,000,000. They are divided into five great classes, according to their color.

The **Caucasian** or **White Race** is the most widely spread, and is the most intelligent and powerful.

The **Mongolian** or **Yellow Race** is found chiefly in northern and eastern Asia. The Chinese, Japanese and Koreans belong to this race.

The **Ethiopian** or **Negro Race** is black, or nearly so. Its native place is in Africa, but it is found in many other parts of the world.

The **Malay** or **Brown Race** inhabits southeastern Asia and the islands of the Pacific and Indian oceans.

The **American Indian**, or **Copper-colored Race**, is found only in North and South America. It is rapidly dying out.

THE LAND WE LIVE IN.

A PRIMARY

HISTORY OF THE UNITED STATES.

CHRISTOPHER COLUMBUS.

Boy and Man.—Christopher Columbus was born in Genoa (jen′o-a), Italy, about 450 years ago. He became a sailor boy and learned the art of sailing ships. He also studied geography and knew how to make maps and charts of lands and waters.

Shape of the World.—Most people of his time thought the world was flat. Columbus thought it was round like a ball, and that by sailing straight out into the ocean and toward the west a ship would in time go around the world, or, at least, as far as Asia (a′shah), with which country many persons in Europe wished to trade.

CHRISTOPHER COLUMBUS.

Columbus Sets Sail.—Columbus was poor. He asked many kings and rich people in Europe to give him ships so that he might sail westward and prove he was right about the shape of the earth. No one would give him ships or help. But after a time, Isabella, queen of Spain, came to his aid. She gave Columbus three small ships. On these he placed 120 sailors, and set sail from the port of Palos on August 3, 1492.

Land Discovered.—After a long voyage, during which Columbus had much trouble with his sailors on account of their fears, land came into sight on October 12, 1492. With much joy a landing was made, and Columbus raised a banner and claimed the land for Spain. It proved to be only a small island named San Salvador (Sal′vah-dore), one of those now called the Bahamas (bah-hah′mahs).

Indians.—Columbus found the people of the island to be of copper color. Thinking he had reached the country of India, in Asia, he called them Indians, a name afterwards given to all the native people of lands still to be discovered in the western world.

Back Home.—On this first voyage Columbus also discovered other islands, among which were Cuba and Little Spain, or Hispaniola (his-pan-ee-o′lah). Then he sailed back to Spain, to tell what he had done. The king and queen gave him a glad welcome, and honored him greatly.

Death of Columbus.—Columbus crossed the ocean three more times, but really never knew he had discovered a new continent. The King of Spain and he quarreled, and the King bound him in chains. Soon afterward he died, a sad and poor old man.

THE TWO CABOTS (Kab′uts).

In the year 1497, John Cabot, who had heard of the discoveries by Columbus, sailed westward in a single ship from the port of Bristol, in England. After a long voyage he sighted land, which he called "The Land First Seen." He thought

DISCOVERERS AND EXPLORERS.

Sir Henry Hudson.
Fernando de Soto.
Jacques Cartier

Hernando Cortez.
Christopher Columbus.
Robert Cavelier de la Salle.

Amerigo Vespucci.
Sebastian Cabot.
Ponce de Leon.

it was an island, but from what we know now it was the mainland of the great New World, or continent of America. He sailed for a long distance down the coast of the new land, and claimed it as belonging to the King of England. He was greatly honored on his return to Bristol. The next year, his son, Sebastian (Se-bast′yan) Cabot, sailed westward from England. He had several ships, and struck the coast of America far to the north. Then he sailed down the coast as far as what is now the State of North Carolina. He also claimed all the land he saw for England.

AMERICUS VESPUCIUS (Ves-poot′che-us).

Americus was an Italian sailor who made four voyages westward, two for Spain and two for Portugal. He struck the mainland of the New World on that part which is now South America. He made maps of the coast and wrote much about what he found; so much, indeed, that people began to use his name, Americus (shortened to America), when speaking about his own discoveries. In the course of time, the name, America, came to be used in speaking of the entire new or western world.

PONCE DE LEON (dah-lah-on′).

Soon after the discoveries by Columbus, many people came over from Spain in search of gold and health. An old man named Ponce de Leon came to seek for a fabled spring called "The Fountain of Youth." In his search he discovered a land which he called Florida, because he found many flowers there. He was killed there in a battle with the Indians.

FERNANDA DE SOTO.

Many other noted people came over from Spain who began to fight the Indians and take their lands in Mexico and South America. In 1539, De Soto landed a Spanish army in Florida and began to fight his way westward against the Indians. He made his way as far as the "Great River," called the Mis-sis-sip′pi, and crossed it, but soon after died. He was buried under the waters of the mighty stream which he had discovered.

THE FRENCH IN AMERICA.

When the King of France found out what was going on in the New World, he said France had as much right there as any other nation. So he sent over ships and men and took up land, mostly along the St. Lawrence River and the Great Lakes. They kept on coming for a period of 150 years, and they named their country Canada. In 1682, one of these Frenchmen, named Robert de la Salle (sal), made his way as far west as the Mississippi River, and floated down the stream to its mouth.

THE ENGLISH IN AMERICA.

Though the Cabots claimed the lands they found for England, she did not send over people to settle them until 1584, when Sir Walter Raleigh (raw′lee) crossed the ocean with a number of men and women to make in the New World an English colony or settlement. His plans failed, but he took back many American plants, such as the potato and tobacco, and introduced them into Europe.

CAPTAIN JOHN SMITH.

Ths first permanent settlement made by the English in America was in 1607. The settlers came in three ships, and landed on an island in the James River, Virginia. They called the settlement Jamestown, after King James, of Eng-

CAPTAIN JOHN SMITH.

land. The settlers became very poor, and would have starved had not one of their number, Captain John Smith, gotten some corn from the Indians. Afterwards the Indians captured Smith and were about to kill him, but Pocahontas, a daughter of the Indian chief, Powhatan, laid her head on that of Smith, so that they could not kill him without killing her too. This touched the heart of the great chief and he let the white man live. Smith afterward was made governor of the new colony, which began to plant and prosper.

HENRY HUDSON.

The Dutch people of Holland felt that they should also take part in settling America. They gave a ship to Henry Hudson, a noted sailor. He discovered the river which was named Hudson, after him. It was not long before Dutch vessels came over in numbers and began to trade with the Indians at Manhattan Island, on which the city of New York now, in part, stands. They called their trading post New Amsterdam, after the city of old Amsterdam, in Holland. From this point the Dutch settlers spread over a large part of what is now New York State, and became a very thrifty people. But England afterward took the entire section from the Dutch and named it New York, in honor of the English Duke of York.

CAPTAIN MILES STANDISH AND THE PILGRIMS.

In England there were many people who did not like to worship God in the way laid down by the king's church. They were treated so badly that quite a number left the country and went to Holland to live. There they were free to worship as they pleased. But they grew tired there, and made up their minds to go to America, not only for the sake of freedom, but so that they could get all the land they wanted. In 1620, they set sail in a ship called the Mayflower, and sighted land at a point off Cape Cod, in the lower part of what was afterward called Mas-sa-chu′setts. One of the number who came was Captain Miles Standish, a brave soldier.

The Landing at Plymouth.—After looking about for a safe place to land, they chose Plymouth (Plim′uth) as a fit spot. They landed there, December 21, 1620, upon a rocky shore. The place is now called Plymouth Rock. At first they suffered much from cold, hunger and sickness. Then the Indians began to attack them, and they had to carry guns when they marched to church under the lead of Captain Standish. These people are spoken of to-day in history as the Pilgrim Fathers.

ROGER WILLIAMS AND THE PURITANS.

Certain other people in England, called Puritans, also left their country and came to America for the same cause as the Pilgrims. They were led by John Winthrop, as their governor, and they settled where Boston now stands, and at other places along the coast of New England, as the country was called. People of other religions, like the Quakers, came with them. The Puritans did not like them, treated them cruelly and tried to drive them out. Among them was a young minister, named Roger Williams. He was forced to flee. He reached a spot which he called Providence, and settled there with many of his friends. This settlement grew into the colony of Rhode Island.

ROGER WILLIAMS AMONG THE INDIANS.

KING PHILIP'S WAR.

The Indians, led by their chief, King Philip, began a war upon the white settlers, who, as he charged, had taken so much land from his tribe that very little was left. The war was a long one, in which many battles were fought and many killed on both sides. Finally King Philip was shot, and the cruel war was ended.

COLONIAL GOVERNORS.

James Oglethorpe.
Peter Stuyvesant.
Sir Henry Vane.
Josiah Winslow
William Penn.
Lord Baltimore.
John Winthrop.
Marquis de Montcalm.
Sir Walter Raleigh.
Capt. John Smith.

THE CHARTER OAK.

The kings of England gave charters to all their colonies in America. These charters told the people how they should be governed. King Charles II. gave a very good charter to the colony of Connecticut. When he died, King James II. wanted to take this charter away from the colony. He sent Andros, governor of the colony, to Hartford to get it. The people met Andros, and refused to give it up, but Andros was about to have his way, when the lights in the room were put out, and when they were relit the charter was gone. After James II. was driven from the throne; the charter was brought back. All the time it was absent it had lain in a hollow oak tree in Hartford, where it had been hidden by one of the colonists. The tree, therefore, took the name of the Charter Oak, and was loved by all the people as long as it stood.

LORD BALTIMORE.

We have just read how badly the Pilgrims and Puritans were treated in England, and why they left there for America. The Catholics were also treated very badly, and resolved to seek a spot where they could worship without hindrance. One of their number, Lord Baltimore, asked the king for a tract of land in America. The king gave him a large tract, which afterwards became the State of Maryland. In 1634, the people sent by Lord Baltimore, landed and built a village at St. Mary's. They paid the Indians for the lands they took with hatchets, knives, beads, etc., and remained at peace with them.

Troubles in Maryland.—Lord Baltimore said that every Christian who came to his Maryland colony should have the right to worship God in his own manner. But certain people came who did not like the Catholics, and great trouble followed. The charter, which had been given to Lord Baltimore by the king, was taken away, and religious freedom was lost in Maryland. But in 1715, the charter was given back to Lord Baltimore's grandson, and the colony began to have peace and freedom of worship again. Many towns were built, among which was one named Baltimore, in honor of Lord Baltimore.

WILLIAM PENN.

There were still other people in England who were badly treated, on account of their religious belief. These called themselves Friends, but the people called them Quakers. One of these was William Penn. His father was an admiral in the British Navy. When he died, his son William became the head of the house of Penn. The king was in debt to the Penn estate. William told him he was going to America with as many members of the Society of Friends as would go along, and that if he, the king, would give him a tract of land there, he would consider the debt due him as paid. The king was glad to pay his debt in this easy way, so he gave William a charter for a large tract of land in America, which he named Penn-syl-va′ni-a, which means Penn's Woods.

Landing of Penn.—William Penn and his colony of Friends came to America in 1682, in the ship **Welcome.** He entered the Delaware river and sailed up until he came to the spot where he founded the city, which he called Philadelphia, which means Brotherly Love. He entered into a treaty with the Indians, paid them for the lands he took, and always lived at peace with them.

Penn's Troubles.—William Penn soon went back to England, but people kept coming to his colony on the Delaware, and it grew rapidly and flourished greatly, but Penn never got much worldly profit out of it, for he was put in prison in England for debt. When he died he left his province to his sons.

JAMES OGLETHORPE.

According to the laws of England, men could be put in prison for debt. The prisons became full of such debtors, many of whom were poor men, honest and willing to work, but they had no chance while in prison. An English soldier, named General James Oglethorpe **(O′-gel-thorpe)** looked upon these conditions with horror. He asked the king for a tract of land in America, to which he might lead these poor prisoners and give them a chance to work. The king gave him the land, which afterwards became the colony and State of Georgia, being named after King George of England.

Savannah Founded.—Oglethorpe reached his province in 1733, bringing a large colony of debtors with him. He laid out the town of Savan′nah. Many people from other parts of Europe joined his colony, and very soon it was proved to Oglethorpe that his plan of settlement was a good one, for the settlers throve greatly. He died at a great age, and took much pride in the city and state which owed their start to him.

BENJAMIN FRANLIN.

Benjamin Franklin was born in Boston in the year 1706. His father made soap and candles, and Benjamin helped him for a time, but afterwards learned the trade of printing with his brother. When seventeen years old he left Boston for New York. Finding no work there, he went to Philadelphia, where he got work. In a few years he had earned enough to set up a printing office of his own, and started a newspaper, which he edited himself with great success. He also published each year an almanac, which he called "Poor Richard's Almanac." It was full of wise and witty sayings, and was read by very many people.

Franklin's Genius.—Franklin grew to be a very great man, and did much to help the growth of Philadelphia. He started the first public library in America, invented a stove which bears his name, and by means of a kite found out that lightning and electricity are one and the same thing.

As a Statesman.—Franklin was a great patriot. When war came with France, he helped to build forts and raise money to buy wagons and food. Again, when war broke out with England, he was sent to France to get the help of that country for the American cause. When he came home, he was much esteemed by the people, and was known all over the world as a great man. He took an active part in making the Constitution of the United States. He died in 1790, an old and honored man.

GEORGE WASHINGTON.

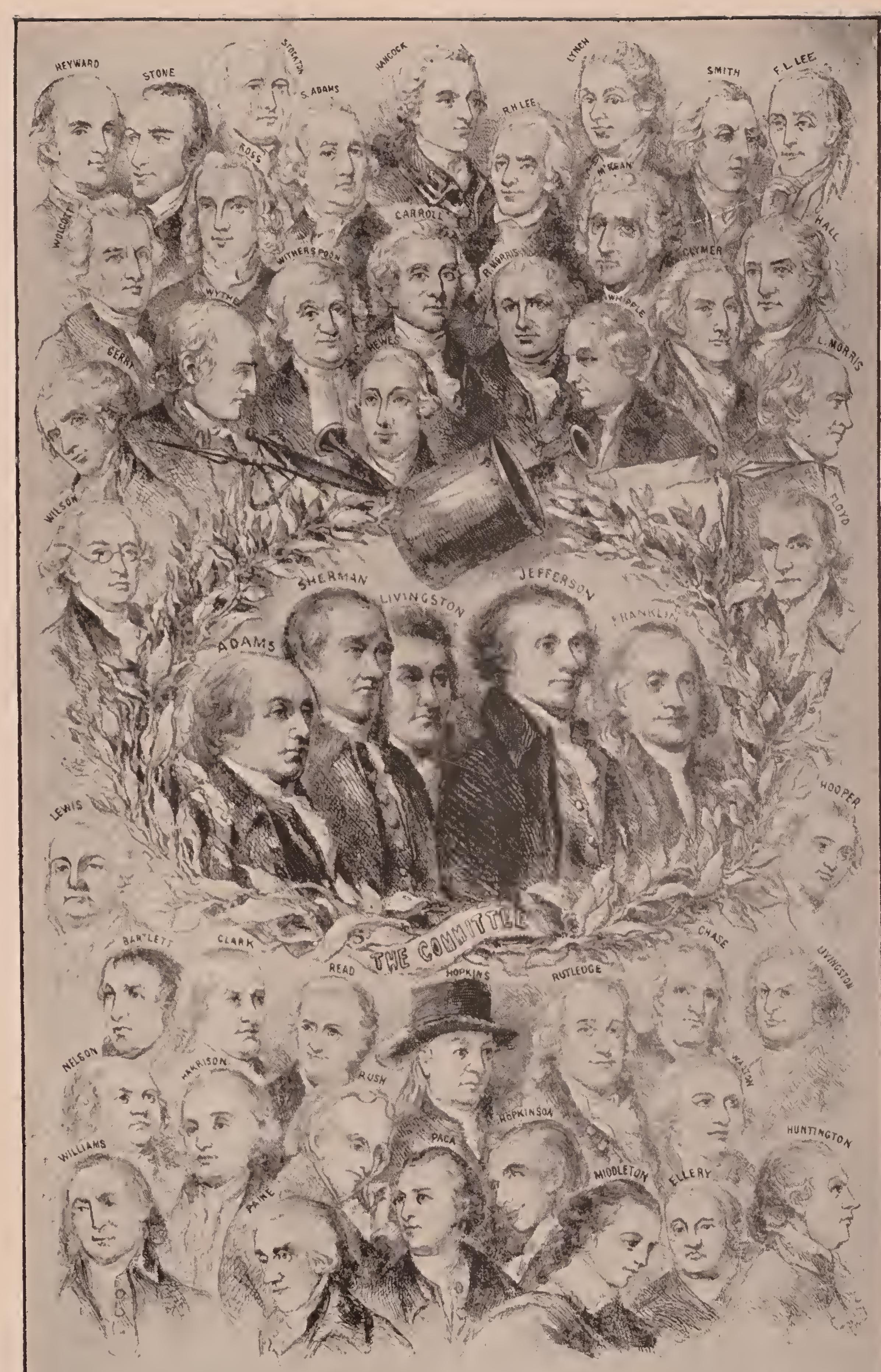
George Washington was born in Virginia, in the year 1732. He learned how to survey or measure land, and at the age of sixteen was hired by Lord Fairfax to survey his large tracts of land in Virginia. But he soon found other work to do. When the English and French were at war for the possession of the country, through which flows the Ohio river, an English army, led by General Braddock, was sent against the French, who had built a fort at a point where the Al′le-ga′ny river joins the Mo-non-ga-he′la to form the Ohio river. Washington went with Braddock's army, and, knowing the woods well and the way of French and Indian fighting, would have been of great help to Braddock. But that General would not listen to Washington's advice. The consequence was that Braddock's army was badly defeated, and he himself was killed. Those who escaped owed their lives to Washington, who kept the body of Virginian soldiers, which he commanded, between them and the Indians. Another general was given command of the English army, who listened to Washington's advice, and after three years of fighting the French fort was captured. The English built another fort on the spot which they called Fort Pitt. Pittsburg now stands where it stood. When this war was over Washington went to his home at Mount Vernon, Virginia, where he spent many years in farming. A little farther on, we will again speak of Washington, as commander of the American army in the War of the Revolution.

THE DRIFT TOWARD REVOLUTION.

The war between England and France ended in 1763. By the treaty of peace France gave to England possession of all the land which had been in dispute in the great valley of the Mississippi river.

The English Colonies.—By this time the English colonies in America numbered thirteen. They were all situated on or near the Atlantic coast, and were nearly all in a flourishing condition, so that England should have been proud of them and anxious for their further welfare. People from these colonies were pushing westward, and rapidly taking up lands and making homes in the new country, which England had got from France, between the Allegheny mountains and the Mississippi river.

Treatment of the Colonies.—George III. became king of England. He was a stubborn king, and began to behave unkindly toward his colonies in America. The colonies wanted to make their own things and do their own trading, but England would not let them. King George asked the Americans to pay for the soldiers he kept in America, and also for the governors and judges. The colonies did not want to do this. They said they did not need any English soldiers here, and that they were able to govern themselves. The king got very angry, and caused his parliament (par′le-ment), a body of men who made laws for England, to lay taxes on the Americans. The first tax was called a stamp tax. It was laid on all paper made or used in the colonies, and even on newspapers. The Americans would not buy the stamps, and they burned all they could get hold of.



SIGNERS OF THE DECLARATION OF INDEPENDENCE.

SIGNING THE DECLARATION OF INDEPENDENCE.

The Tax on Tea.—Then England laid a tax on goods sent to America. Among such goods was tea, on which a heavy tax was laid. When ships with tea were sent to Boston the people would not let them land. They even went on board a tea ship at night, dressed as Indians, and threw the tea overboard. This made the king so angry that he ordered the port of Boston to be closed against all ships, except his war-ships. He also sent soldiers to make the people obey his laws.

Gathering of the Americans.—The colonists in America now thought they must do something to protect themselves. All the colonies sent their best men to a meeting in Philadelphia. This meeting was called a Congress, and it was the first of the kind ever held in America. It sent a letter to the king, asking for the same rights Englishmen had at home. The king refused them such rights. Then the Americans, seeing that war was about to come, began to gather arms and to drill men as soldiers.

OPENING OF THE WAR.

The First Battle.—One night the British soldiers started from Boston to Concord to destroy the powder and guns of the Americans, which had been gathered at the latter place. A sturdy man by the name of Paul Revere, started on horseback for Concord to warn the people that the British soldiers were coming. As he passed through the village of Lexington on his way, he put the people on their guard. They gathered in numbers across the path of the British soldiers, who fired upon them, killing many of their number. This was the first battle of the war, which was called the War of the Revolution; that is, the war which gave this country its freedom from England. It was called the battle of Lexington, and was fought on April 19, 1775.

Battle of Concord.—After this, the British marched to Concord to destroy the stores there. But Paul Revere had warned the people, and they had hidden all the stores, and formed in line to meet the British. A battle took place at Concord, in which many were killed on both sides. The British soldiers marched back to Boston, around which city the Americans began to gather in great numbers with their guns, ready to fight. The whole country was now in a state of excitement, for war was really on in earnest. A hard battle took place at Bunker Hill, near Boston, in which the British learned that the Americans could fight.

The Call for Washington.—The American Congress met again and called George Washington to take command of the armies which were forming. He took command at Cambridge, near Boston, and soon began to put his soldiers in shape to fight. The British feared to remain in Boston, so they sailed away in their ships and never came back.

Declaration of Independence.—The Congress, which had called Washington to command, was still in session. It formed and passed a Declaration of Independence from England, on July 4, 1776. We have celebrated this day every year when the 4th of July comes round. This great paper said that the American colonies were forever free from English rule. Of course, it meant that the war was to be fought until full freedom was gained. When the Declaration was passed the people were filled with joy, and the old liberty bell at Philadelphia rang out loud and clear.

WASHINGTON IN THE REVOLUTION.

When the British army left Boston, Washington marched his army to New York, whither the British had gone with their fleets and soldiers. Around New York many battles were fought, in which the Americans were beaten. Washington retreated across New Jersey and crossed the Delaware river, with the British close after him. Winter came on and the two armies encamped on opposite sides of the river.

Battle of Trenton.—A large number of German soldiers, called Hessians, were in camp in Trenton, N. J. On the night of Christmas, 1776, Washington crossed a part of his army through snow and ice in boats back across the Delaware and marched to Trenton, where he completely surprised the Hessians and took a thousand of them prisoners of war. A few days later he won a battle at Princeton against the main body of the British army.

Valley Forge.—The next year (1777) the British army was sent in ships, by way of Chesapeake Bay, to capture Philadelphia. Washington met this army at the Brandywine Creek, below Philadelphia. A great battle was fought, in which the Americans were defeated. The British marched on and entered Philadelphia, where they encamped for the winter. Washington retreated to Valley Forge, above Philadelphia, where his army spent a dismal winter without sufficient food or clothes. Meanwhile, a British army, which was marching from Canada to New York, was defeated. When the British in Philadelphia heard of this, they left the city for New York. They were pursued by the Americans and defeated in several battles. Though Washington was now gaining victories over the British, he was very much put out by the fact that one of his bravest generals, named Benedict Arnold, whom he had left in command of the army, which held West Point, on the Hudson river, turned traitor and went over to the British side to fight against his country.

Cornwallis at Yorktown.—Seeing they could not make much headway against Washington's army in the north, the British turned their main strength, both of ships and men, to the Southern States. Here many battles were fought, and the victories for either side were about even. At length, Lord Cornwallis, one of the British generals, managed to reach Yorktown, in Virginia, with his army. He was followed up by the American army of the South, which fortified itself all around Yorktown. Word was sent to Washington, who was near New York with his main army, that he should send help as quickly as possible to the Americans at Yorktown. He immediately began a secret march to Yorktown with five thousand of his best soldiers. With this force added to their own, the Americans were now strong enough to keep Cornwallis from escaping by way of the land. But he might yet make his escape by way of the sea. Very fortunately for the Americans, just at this time a French fleet of warships, which had been sent over to help fight the British, appeared at Yorktown and cut off the escape of Cornwallis and his army by way of the sea. He saw he could hold out no longer, so he surrendered his army as prisoners of war, on October 17, 1781. This was the end of the War of the Revolution, which had lasted for nearly seven years.

Washington as President.—The news of the surrender of Cornwallis and the end of the war caused great joy in all the American colonies. Washington gave up his command and went back to his farm at Mount Vernon. Then all the colonies sent their wisest men as delegates to a convention or Congress at Philadelphia. There they made a great writing, which was called a Constitution. Under this all the colonies agreed to live as States of one grand union, which took the name of the United States of America. This was in 1787. Washington was elected as the first President of the United States. He served for a term of four years and was chosen a second time for four years more, when he again went back to his farm. Soon afterwards (1799) he died. The whole country mourned him as "First in war, first in peace and first in the hearts of his countrymen."

SPREADING WESTWARD.

As soon as the Revolutionary War was over, many brave persons, called pioneers, went westward to take up lands and build houses in the Mississippi valley. Among these was Daniel Boone, a great Indian fighter, who did much to bring settlers to what afterwards became the States of Kentucky and Tennessee. Other brave pioneer leaders, with their bands of settlers, drove the Indians back and took up lands in what afterwards became the States of Ohio, Indiana and Illinois.

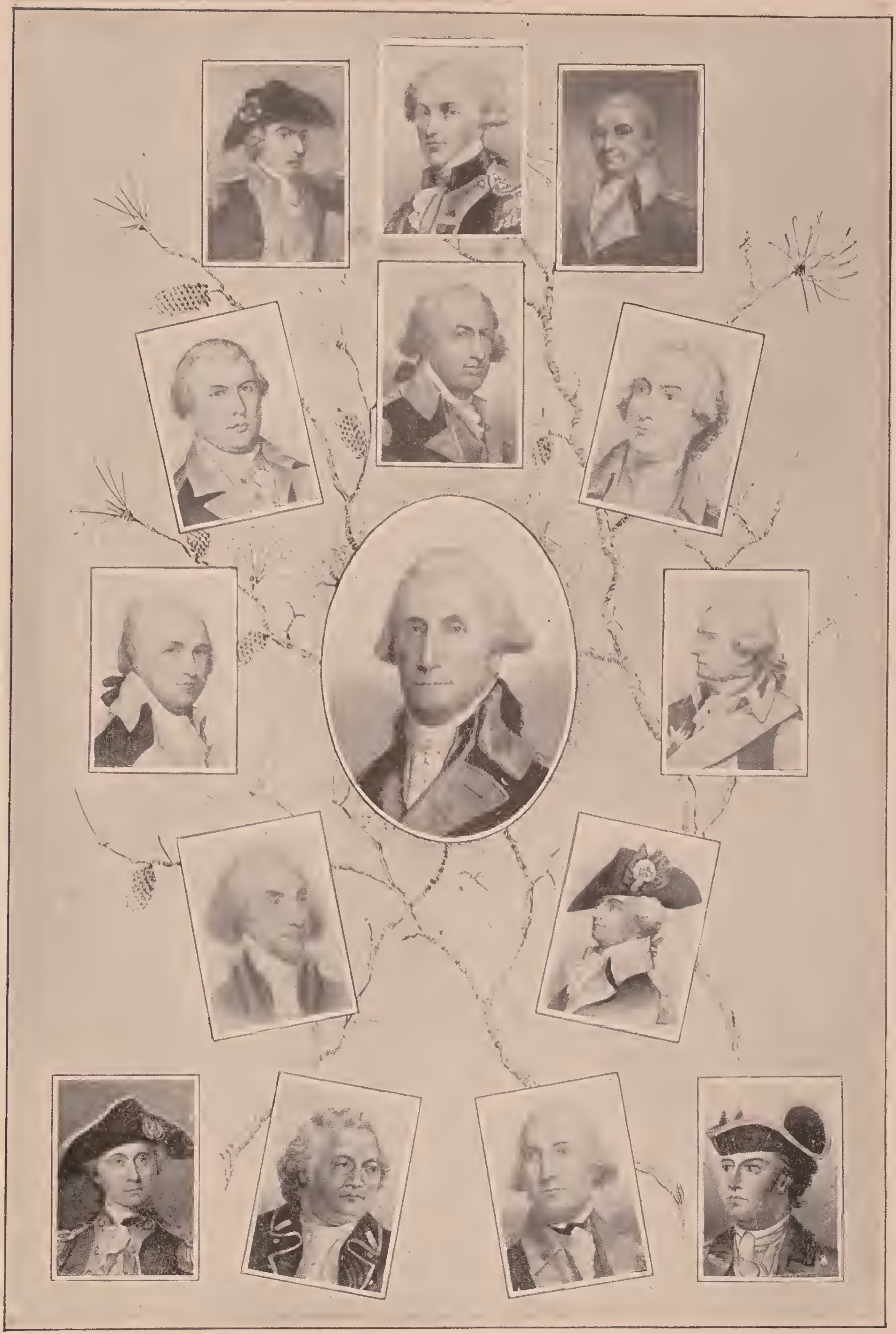
THE EARLY PRESIDENTS.

Times like those of the Revolution and the following years brought forth many great men. In the army were such brave generals as Anthony Wayne, Philip Schuyler, Francis Marion, Nathaniel Greene, Marquis de Lafayette, who came over from France, and many others of equal fame.

In the councils of the nation were Samuel Adams, Patrick Henry, Robert Morris, Alexander Hamilton, and a host of others, whose speeches stirred up the people against England, and whose advice was of great service to Washington in starting the new government.

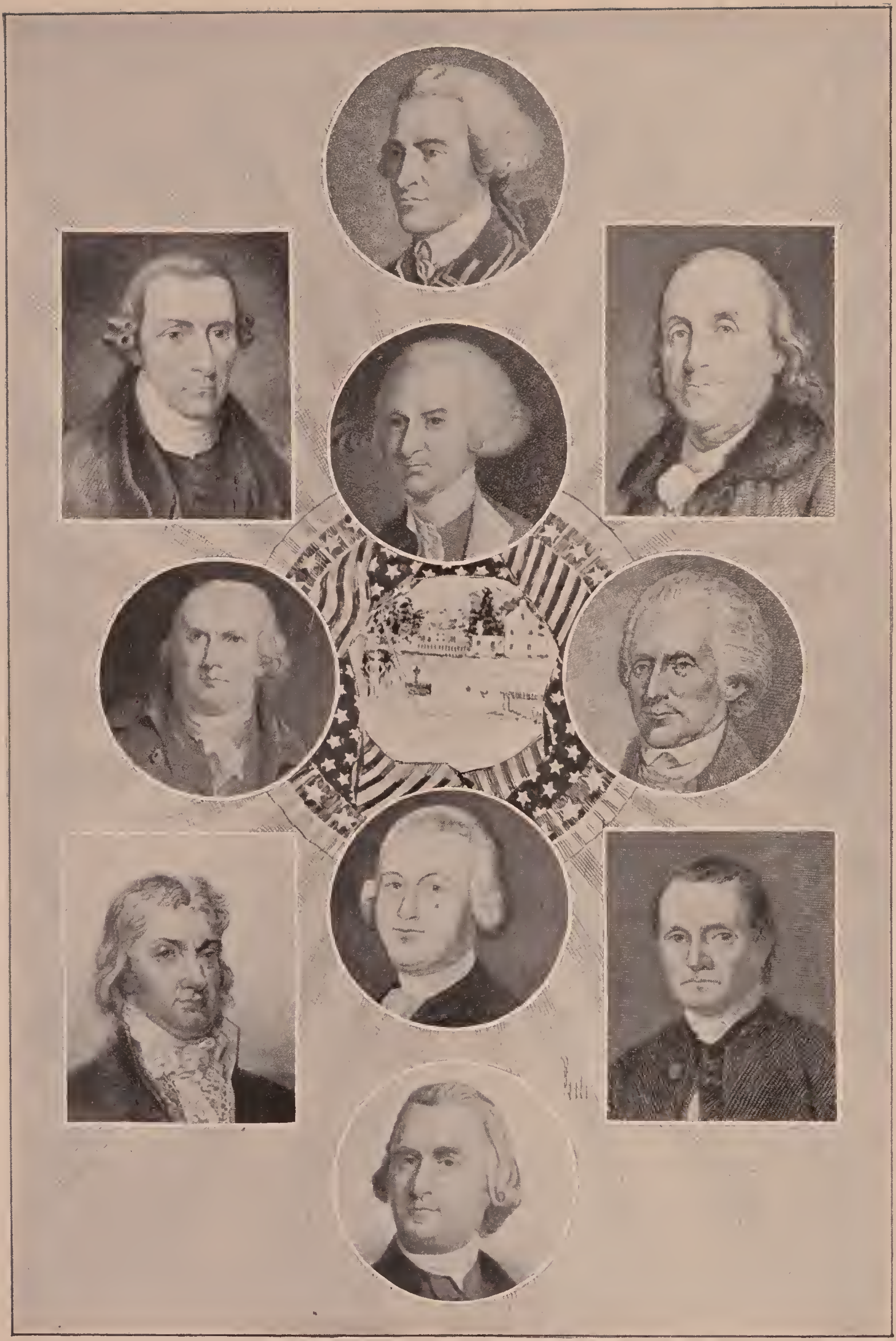
The next President after Washington was John Adams, of Massachusetts. His term of office was from 1797 to 1801.

Thomas Jefferson.—The third President was Thomas Jefferson, of Virginia. Washington and Adams belonged to the party called "Federal." Jefferson founded a new party, which he called "Republican." He was elected twice, and his terms of office extended from 1801 to 1809. He had become very great in the eyes of the people as the author of the Declaration of Independence and as Minister to France. When he took office, all the country west of the Mississippi river belonged to Spain. Spain sold it to France. Jefferson, with the consent of Congress, bought it from France for $15,000,000. This was called the



GENERALS OF THE REVOLUTION.

Francis Marion. Lafayette. Henry Knox.
Nathaniel Greene. Horatio Gates. Charles Lee.
Henry Lee. George Washington. Rochambeau.
Philip Schuyler. Anthony Wayne.
John Paul Jones. Israel Putnam. Baron Steuben. John Sullivan.



STATESMEN OF THE REVOLUTION.

John Hancock.

Patrick Henry.

Benjamin Franklin

John Dickinson.

Robert Morris.

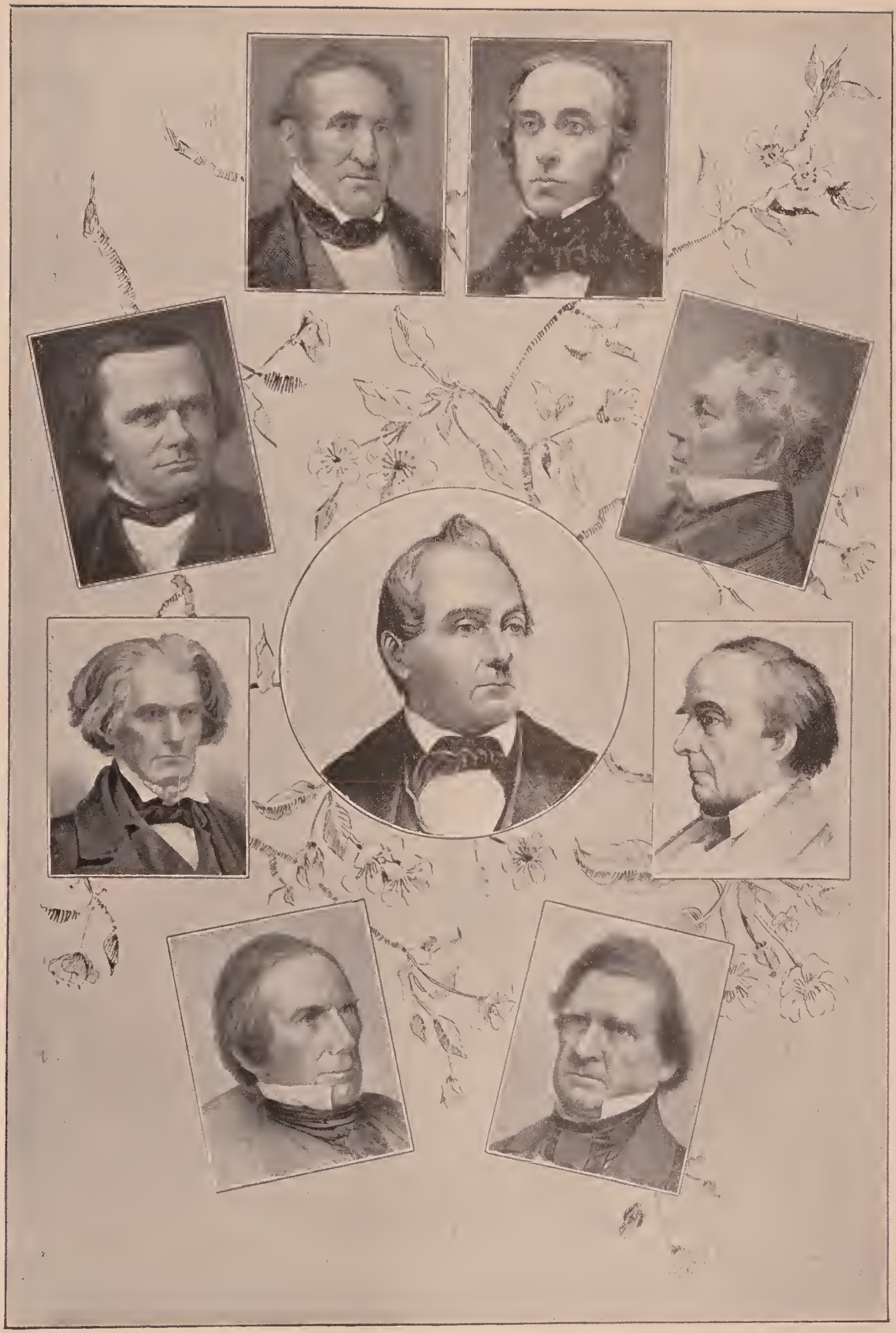
Richard Henry Lee.

James Otis.

Robert R. Livingston.

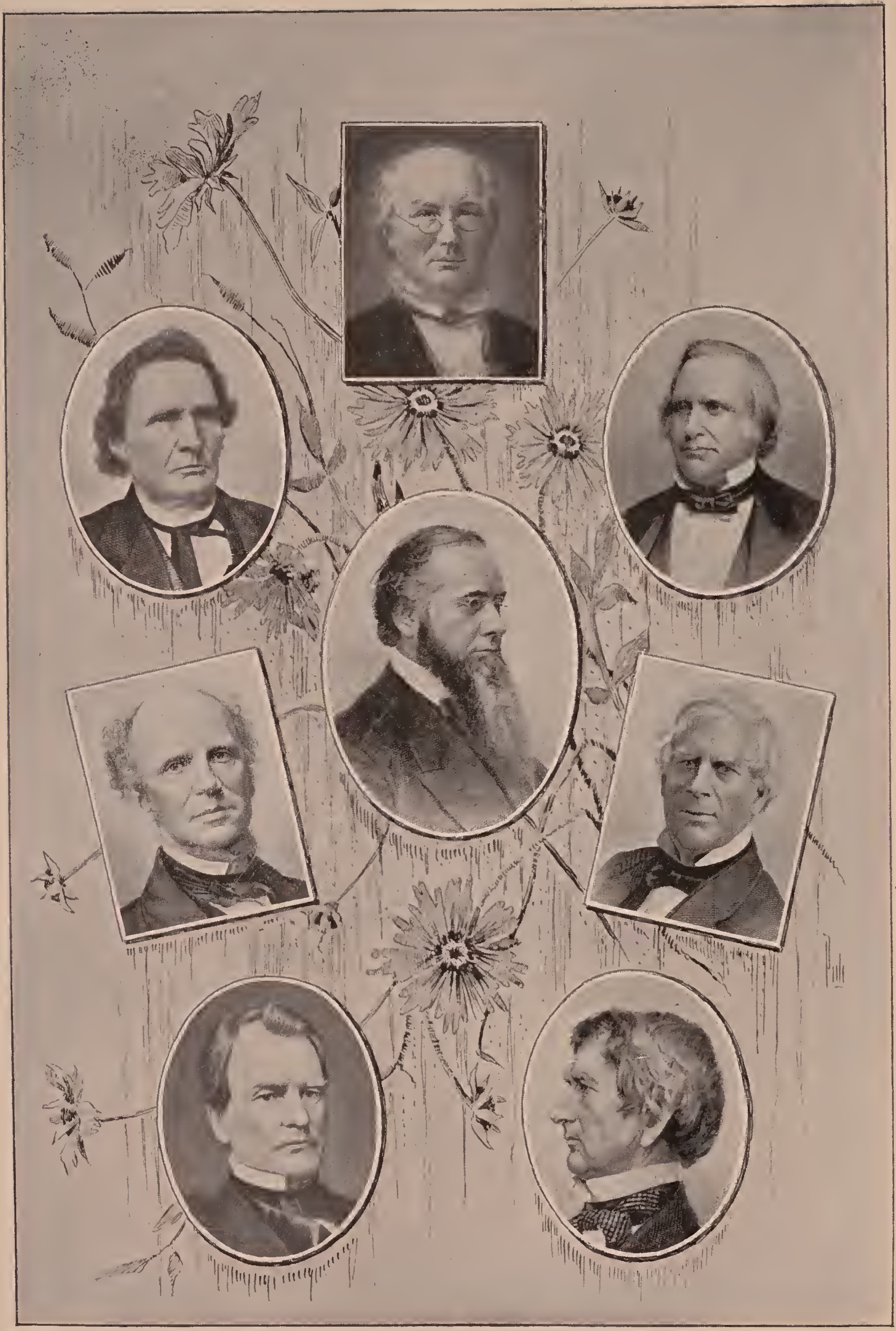
Roger Sherman.

Samuel Adams.



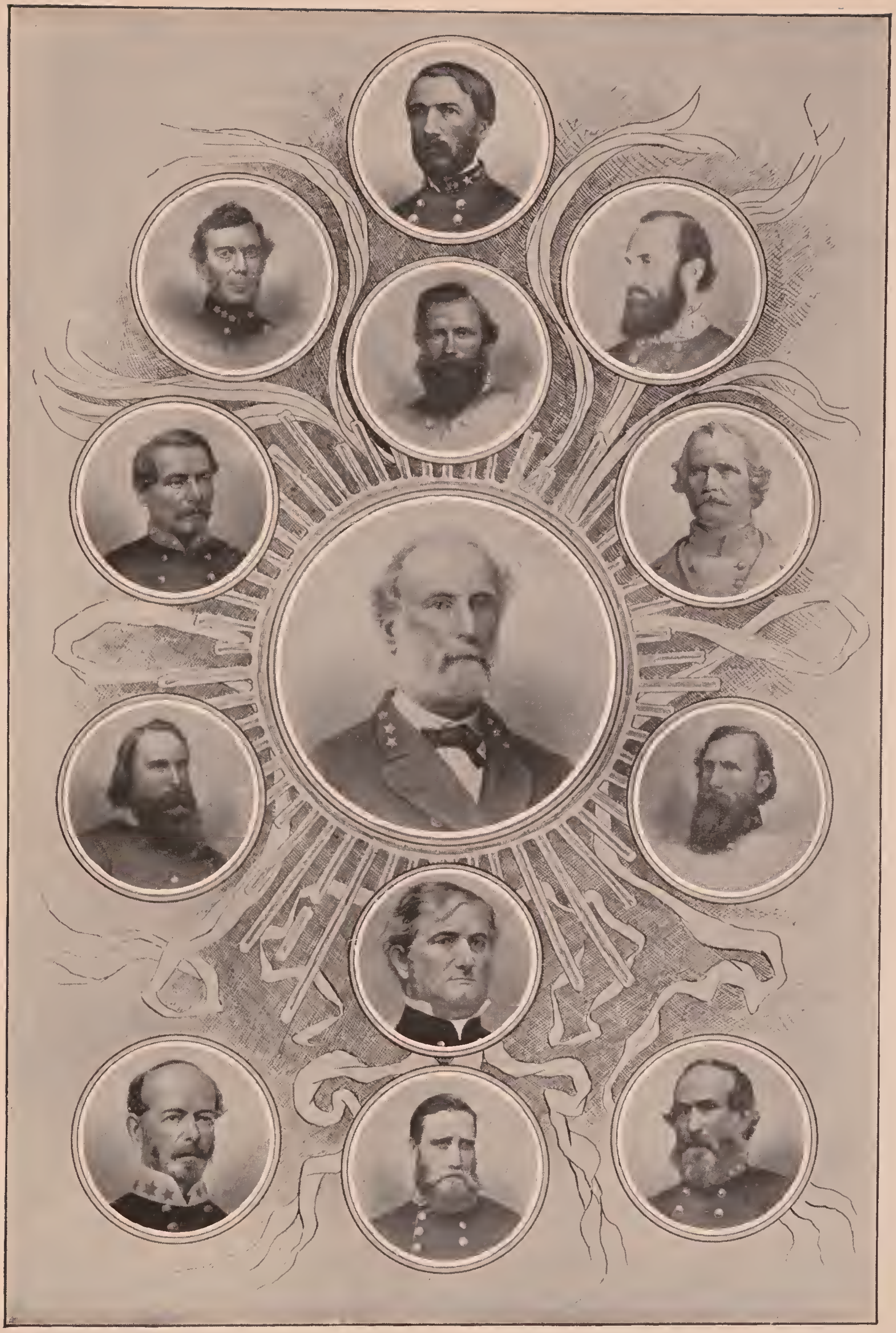
STATESMEN OF THE MIDDLE PERIOD.

Thomas H. Benton.
Robert Winthrop.
Stephen A. Douglas.
Edward Everett.
Silas Wright.
John C. Calhoun.
Daniel Webster.
Henry Clay.
W. L. Marcy.



STATESMEN OF THE CIVIL WAR PERIOD.

Horace Greeley.
Thaddeus Stevens.
Henry Wilson.
Edwin M. Stanton.
Horatio Seymour.
Thurlow Weed.
B. F. Wade.
Wm. H. Seward.

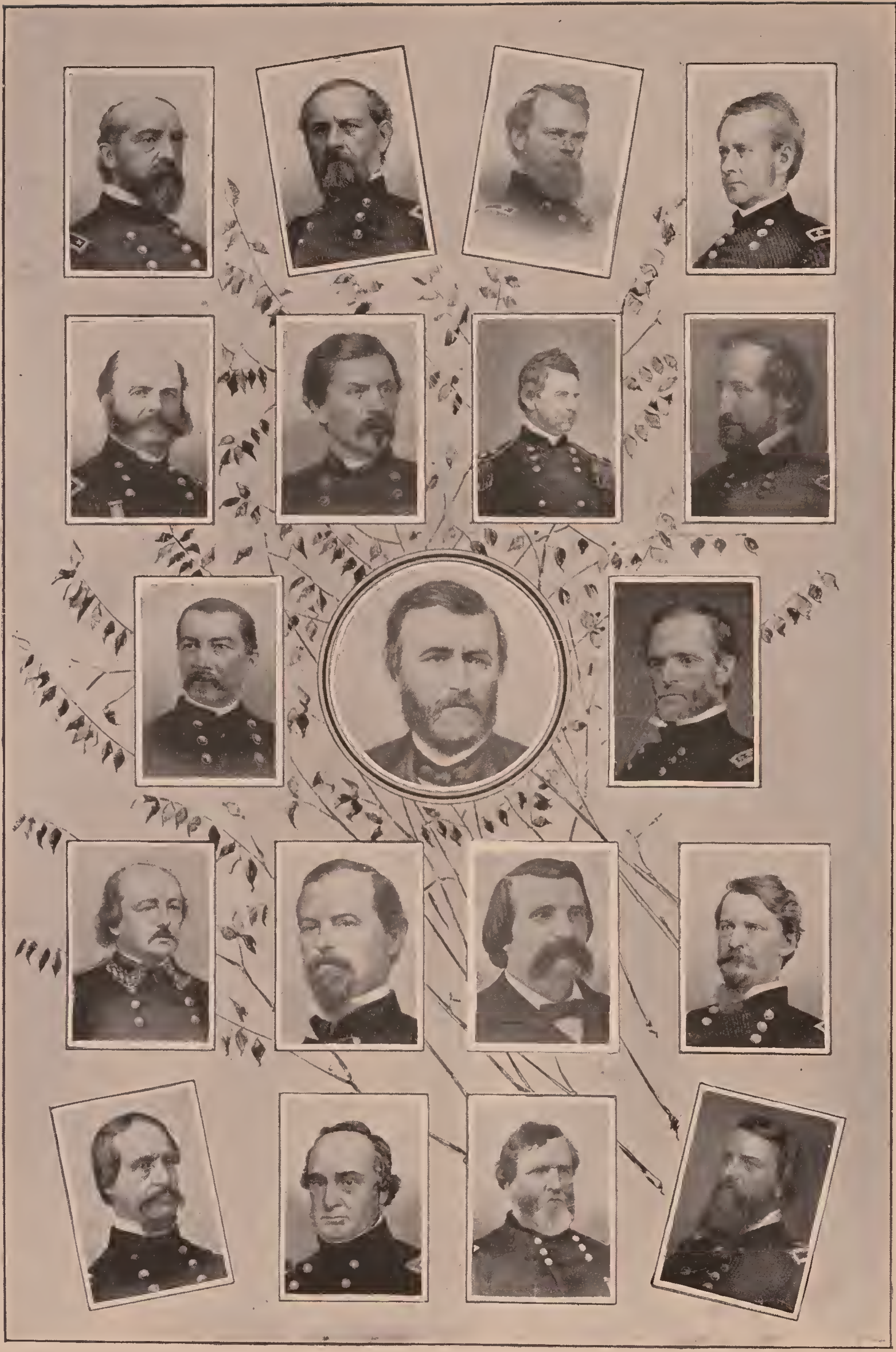


CONFEDERATE GENERALS.

Braxton Bragg.
P. G. T. Beauregard.
James Longstreet.
Joseph E. Johnston.

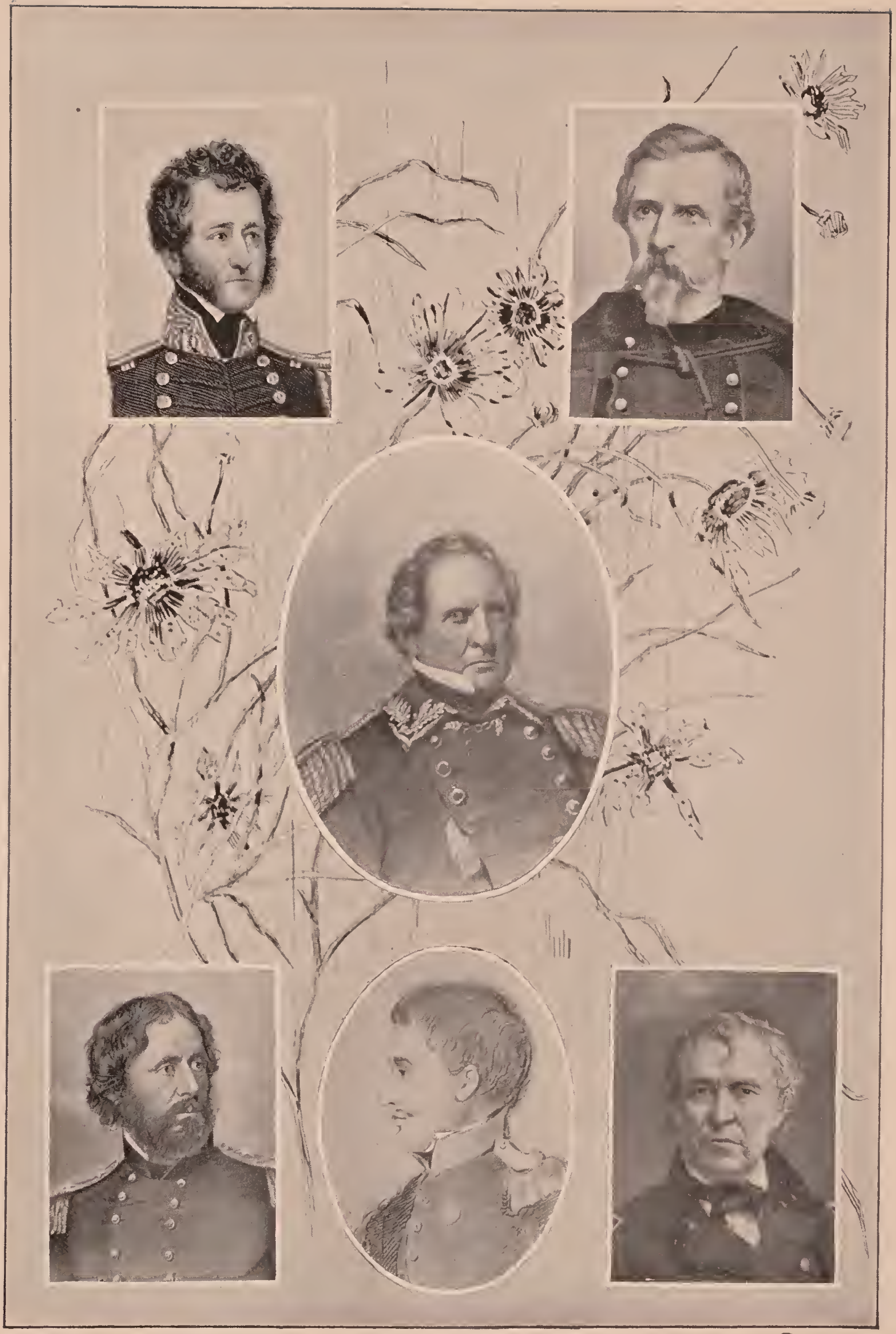
David H. Hill.
J. E. B. Stuart.
Robert E. Lee.
Leonidas Polk.
John B. Hood.

Thomas Jonathan Jackson.
A. S. Johnston.
A. P. Hill.
Jubal A. Early.



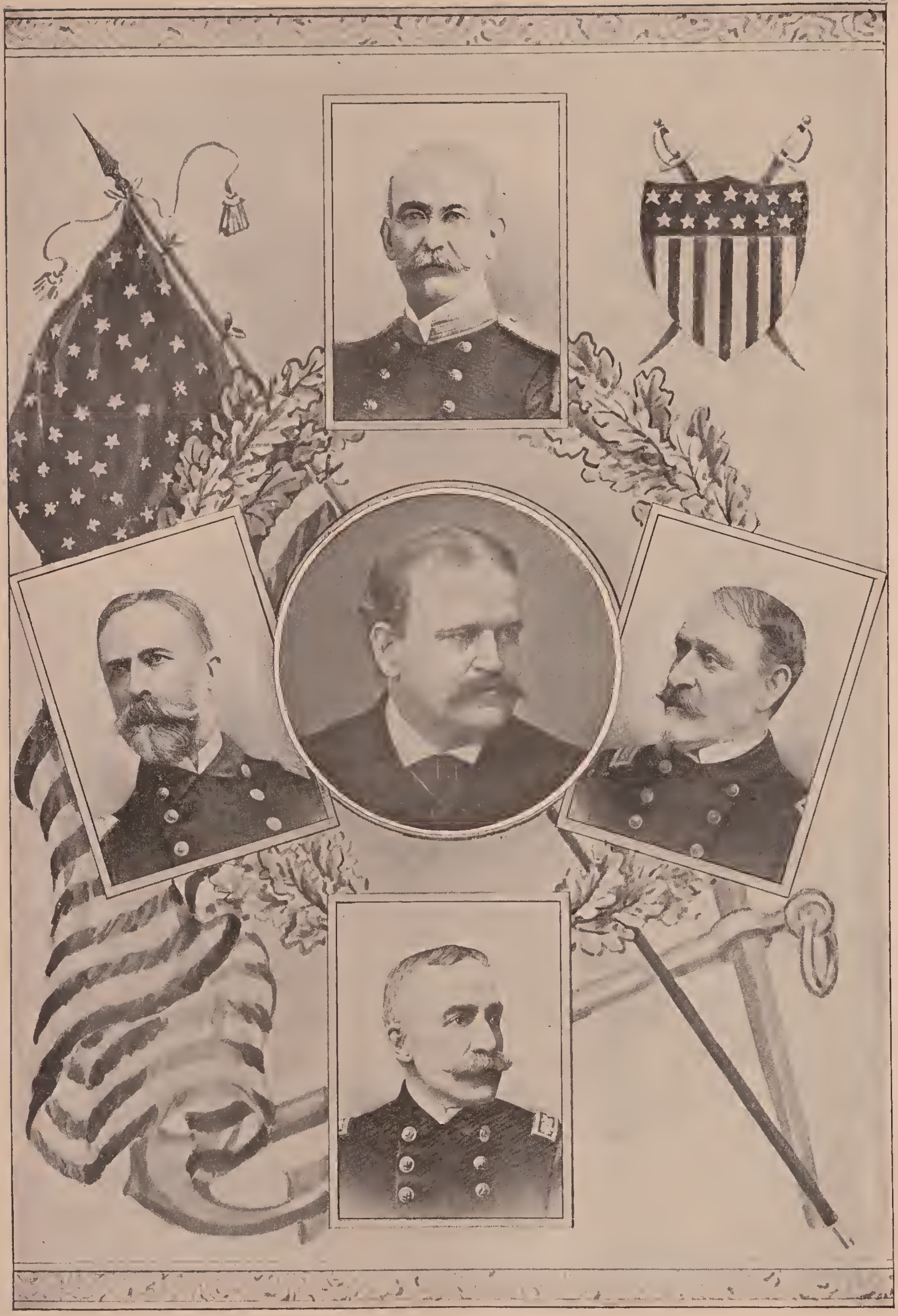
GENERALS OF CIVIL WAR.

George Gordon Meade. D. C. Buell. James B. McPherson. Joseph Hooker.
A. E. Burnside. George B. McClellan. Nathaniel P. Banks. W. S. Rosecranz.
Philip H. Sheridan. Ulysses S. Grant. William T. Sherman.
Benjamin F. Butler. Irvin McDowell. John A. Logan. Winfield S. Hancock.
David Hunter. Henry W. Halleck. George H. Thomas. John Pope.



COMMANDERS IN THE MEXICAN WAR.

R. F. Stockton.
John C. Fremont.
Winfield Scott.
Santa Anna.
Philip Kearney.
Zachary Taylor.



NAVAL COMMANDERS OF WAR 1898.

Charles D. Sigsbee.

William T. Sampson.
John D. Long.
(*Secretary of Navy.*)
Winfield S. Schley.

George Dewey

"Louisiana Purchase." In order to find out what kind of a country it was, he sent an expedition westward, under the lead of Lewis and Clark. They traveled until they reached the Pacific Ocean, and then came back over the same route. Jefferson was much pleased with the report they made of the country traveled through.

James Madison, of Virginia, followed Jefferson as President. He was elected twice, his two terms extending from 1809 to 1817. During his term, war broke out between the United States and England. It was called the War of 1812, and lasted for three years. During this war the American army suffered many defeats, but the American navy gained many battles at sea. The last land battle of this war was fought near New Orleans. The Americans were led by General Andrew Jackson, and they gained a great victory over the Brtish, but it was a useless victory, because the battle was fought after a treaty of peace between the United States and England had been signed. News of the treaty had not reached Jackson, when the battle was fought.

James Monroe, of Virginia, became President after Madison. He was elected twice, and his two terms of office were from 1817 to 1825. During his terms Spain sold Florida to the United States, the war against the Florida Indians was fought, and the doctrine was announced that no foreign countries should establish monarchies on the Western Continent. This is known as the "Monroe Doctrine."

John Quincy Adams, of Massachusetts, followed Monroe as President. He was elected for only one term, serving from 1825 to 1829.

ROBERT FULTON.

About the beginning of the nineteenth century, that is, the century which entered with the year 1800, there was much talk of using steam for the running of large boats on water. Several persons invented boats for this purpose, but it was not until 1807 that Robert Fulton made one which moved safely by means of steam. He called it the "Clermont." It was started from New York and ran up the Hudson river to Albany. It continued to run for some years between those two cities, and from that time on steamboats grew into general use.

ANDREW JACKSON.

Andrew Jackson was born in Tennessee in 1767. He led the American troops in many battles against the Indians, and gained a great victory over the British at New Orleans during the War of 1812. After serving in many high offices he was elected President, to succeed John Quincy Adams. He was elected twice, and his term of office was from 1829 to 1837. His terms were exciting ones, but the people stood stoutly by him.

WEBSTER AND CLAY.

Daniel Webster became a United States Senator from Massachusetts in 1827. He proved to be one of the leading orators in the country, and portions of his great speeches are still spoken by children in our schools. Henry Clay, of Kentucky, was also United States Senator, and a very powerful orator. He was much loved by the Whig party, and ran twice for President, but failed both times.

WILLIAM HENRY HARRISON.

Andrew Jackson was succeeded as President by Martin Van Buren, of New York State. He served one term, from 1837 to 1841. He was succeeded by General William Henry Harrison, of Ohio, who had gained great fame for defeating Tecumseh, the noted Indian leader of the West, at the battle of Tippecanoe, and again in Canada, where Tecumseh was killed. Harrison lived only a month after he was elected President. John Tyler, who was Vice-President at the time of Harrison's death, became President.

THE WAR WITH MEXICO.

In 1847, while James K. Polk, of Tennessee, was President, war broke out between the United States and Mexico over the ownership of Texas, which Mexico claimed. General Zachary Taylor, in command of the American army, defeated the Mexicans at Buena Vista, and became a national hero, under the name of "Old Rough and Ready." The main American army, led by General Winfield Scott, entered Mexico at the port of Vera Cruz, and marched toward the city of Mexico, the capital of the country. Many battles were fought during this march, in all of which the Americans were successful. The war ended with the entry of Scott's army into the Mexican capital. In the treaty of peace, which followed, Mexico gave up her claim on Texas, and in addition ceded to the United States a very large territory, part of which became the State of California.

DISCOVERY OF GOLD.

In 1848, gold was discovered in California, on lands owned by one Captain Sutter. The next year a great number of people rushed to California from all over the country, many of whom made fortunes, but most of them lost all they had. They were called "Forty-niners." In seven years' time California produced nearly five hundred million dollars in gold.

ABRAHAM LINCOLN.

After James K. Polk, General Zachary Taylor was chosen President, but died in about a year afterward. The Vice-President, Millard Fillmore. filled out his term of office. After him, Franklin Pierce, of New Hampshire, served as President, from 1853 to 1857; and after him James Buchanan, of Pennsylvania, from 1857 to 1861. Then Abraham Lincoln, of Illinois, was elected President by the Republican party. The war between the States now broke out, and Lincoln's administration was filled with troubles, but he bore them patiently and ably, and the people, especially the soldiers, learned to love him. His greatest act was the putting forth the Emancipation Proclamation, which set all the slaves free on January 1, 1863. So pleased were the people with him that they elected him President a second time for the term beginning in 1865. But he did not live long after this, for he was shot by an enemy on April 14, 1865. The whole country mourned him, as if every one had lost his best friend. Even the people of the South were sorry, for they had learned he was their friend and not their enemy.

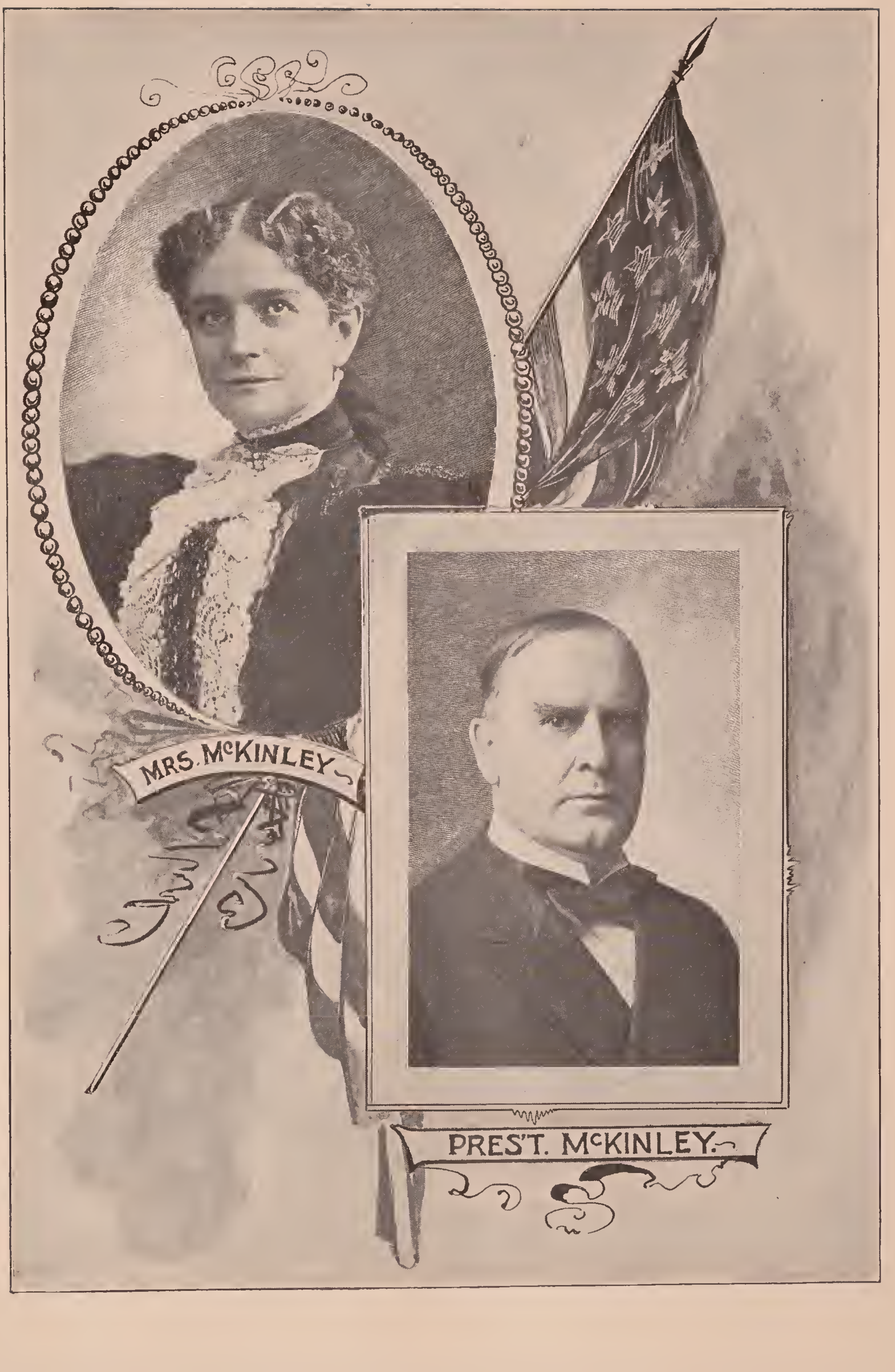
THE CIVIL WAR.

A Southern Confederacy.—The great war between the States, called the Civil War, broke out in 1861, by the capture of Fort Sumter by soldiers of the South. For years the Northern and Southern States had differed over the question of holding slaves. The South believed it right, the North believed it wrong, to hold slaves. When Abraham Lincoln was elected President in 1860, the Southern States said they would not live in a United States that had a President who opposed slavery. So, eleven of those States went out of the union (seceded) and set up a government of their own, which they called the "Confederate States of America." They elected Jefferson Davis, of Mississippi, President, and Alexander H. Stevens, of Georgia, Vice-President.

The Battling Armies.—President Lincoln and the Congress at Washington said the Union of States should not be thus broken up. So both sides gathered great armies, and the fight was on in earnest. Both the Union and Confederate armies were led by able generals. General Robert E. Lee, of Virginia, became leader of the Confederate armies. He had under him such brave generals as Thomas J. Jackson—"Stonewall Jackson"—Joseph E. Johnston, P. G. T. Beauregard, and many others equally brave.

The Union, or Northern, armies passed at first under the command of several noted generals, among whom were Generals Irwin McDowell, George B. McClellan, George G. Meade, Ambrose E. Burnside, and others. After these armies were reorganized in 1864, General Ulysses S. Grant was made commander of all the Union armies, and had under him such noted generals as Meade, Sherman, Thomas and Sheridan.

End of the War.—The war lasted for four years, from 1861 to 1865. Very many great battles were fought, both by land and sea. The two armies numbered at times over 500,000 men each, and in some of the battles many thousand men fell on each side. General Lee at one time reached a point with his army as high up in the north as Gettysburg, in Pennsylvania. Here a fierce battle was fought, lasting for three days. This was in 1863. Lee and his army were defeated and driven back toward Richmond, the capital of the Confederacy. This battle was said to be the turning-point in the war, for the Confederates never recovered the ground they then lost. In 1864, General Grant advanced his army to the south side of Richmond, which city Lee was compelled to give up. Soon after Lee surrendered his entire army to Grant at a place called Appomattox, in Virginia. This was April 8, 1865. Meanwhile, General William T. Sherman, one of Grant's ablest generals, had marched an army from Atlanta, Ga., to the sea at Savannah, and thence north and into North Carolina, where he met a Confederate army under General Joseph E. Johnston. As soon as Johnston heard of Lee's surrender to Grant, he saw there was no use fighting further, so he surrendered his army to General Sherman. Thus, the great Civil War was ended and the Southern Confederacy ended with it. All the States, which had gone out of the Union soon afterwards came back, and the Union was once more whole again.


MRS. McKINLEY
PRES'T. McKINLEY.

PRESIDENT THEODORE ROOSEVELT.

GRANT AS PRESIDENT.

The people, in their respect for General Grant, elected him President for two terms, from 1869 to 1877. He served well in office, but was afterwards unfortunate in business. He took sick with cancer, and died at Mt. McGregor, a summer resort in New York State, in July, 1885.

LATER PRESIDENTS.

Rutherford B. Hayes, of Ohio, became President after Grant. He served one term, from 1877 to 1881. After him came James A. Garfield, of Ohio, as President. He was shot by a crazy man, named Guiteau, and died from the wound, on September 19, 1881. Following him came Grover Cleveland, of New York State, the first Democratic President since the Civil War. His term was from 1885 to 1889. The next President was Benjamin Harrison, of Indiana, who served from 1889 to 1893. Then Grover Cleveland was again elected President, and served from 1893 to 1897.

WILLIAM McKINLEY AS PRESIDENT.

William McKinley, of Ohio, was elected President for the term from 1897 to 1901. It was during this term that war broke out between the United States and Spain, on account of Spanish cruelty toward the people of Cuba, which belonged to Spain. The feeling in the United States against Spain was made very bitter by the blowing up of one of our battleships, named the Maine, in the harbor of Havana, whither she had gone on a friendly visit. This outrage was blamed on the Spaniards.

The War With Spain.—This war began April 21, 1898. An American fleet, under the command of Commodore Dewey, which was on the coast of China, was ordered to go to Manila, the capital of the Philippine Islands, which belonged to Spain, and where a large Spanish fleet was stationed. Dewey set sail promptly, and, on May 1, 1898, attacked and destroyed the Spanish fleet without the loss of a ship or a man. It was a most wonderful naval battle. Soon afterwards Manila surrendered to the American forces.

The War In Cuba.—An American army was sent to Cuba, and at the same time our fleet, under Admiral Sampson, blockaded the Cuban ports. The army landed near Santiago, a Spanish stronghold on a harbor of the same name, in which Admiral Cervera, of the Spanish navy, had taken refuge with his fleet. The army captured Santiago. This forced Cervera to flee with his warships. As soon as he sailed out of Santiago harbor to escape, his ships were attacked by Sampson's fleet, and everyone of them destroyed. Only one American sailor was killed. This was as great victory as that at Manila. The Spaniards had enough of the war and sued for peace, after only four months of fighting. By the treaty of peace the United States came into possession of the Philippine Islands and the island of Porto Rico, and Spain gave up Cuba to the Cubans forever.

Many of the people of the Philippines, who did not like either Spain or the United States, started a war against the latter country. Many soldiers had to be sent over to conquer these people. Several battles were fought before the American soldiers conquered the Filipino disturbers.

PRESIDENT ROOSEVELT.

President McKinley was elected to office a second time, and his term would have extended from 1901 to 1905. Theodore Roosevelt, of New York, was elected Vice-President at the same time. While President McKinley was on a visit to the Exposition at Buffalo, N. Y., and while he was shaking hands with the people in public, he was shot by an anarchist, named Czolgosz, and died of the wounds received on September 14, 1901. Vice-President Roosevelt succeeded him, and said to the American people he would see to it that he would do for them all that President McKinley had promised to do. The death of McKinley was a great blow to the people, and he was universally mourned, for he was a very popular and much loved President. President Roosevelt was elected to the Presidency for the full term from 1905 to 1909. He made a very active and popular President, and was noted for his efforts to correct many wrongs which the railways and big corporations had been doing to the people.

OUR BODIES.

IMPORTANCE OF THE SUBJECT.

When we look at a locomotive rushing swiftly along with its heavy load of cars; when we see a watch with its steady tick, tick, measuring the minutes and the hours, day after day and year after year; when we see any of the wonderful pieces of machinery that are so common in these days, we have a natural desire to examine them for the purpose of finding out how they are made and how they are able to do their wonderful work.

Our bodies are more wonderful than any machine that ever was invented. Just as a workman must understand the machine which he is running in order to make it do its best work and to avoid damaging or ruining it, so each of us ought to know enough about our bodies to keep them strong and healthy.

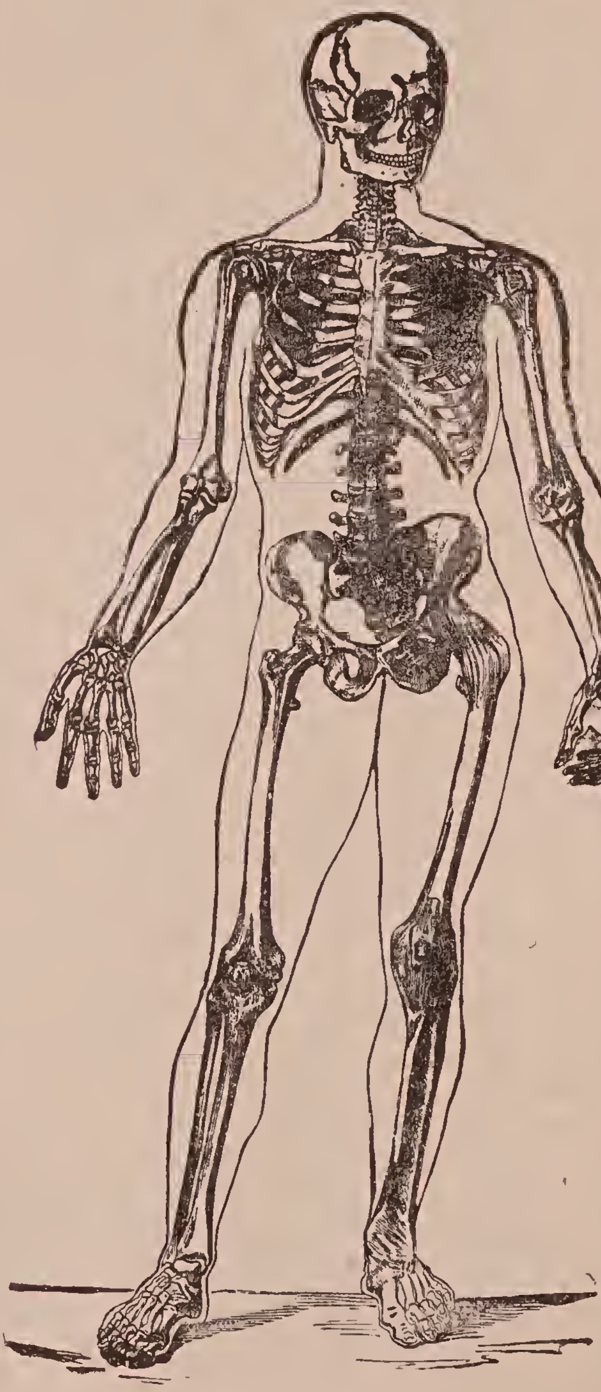
The Great Divisions of the body are the head, the trunk, and the limbs.

The Head is made up of the brain-case and the face. The brain-case is a strong, rounded box of bone which holds and protects the brain. Little hollows in the brain-case contain the inner parts of the ears. Hollows in the face provide spaces for the mouth, the eyes, and the nose.

The Trunk is divided into two parts by a strong muscle, called the diaphragm (di′a-fram). The upper part is called the chest and contains the heart, and the lungs. These are protected by a sort of bony cage, formed by the ribs and the backbone. The lower part of the trunk is called the abdomen (ab-do′men), and contains the stomach, the intestines, the liver, the kidneys and other organs.

The Limbs.—The upper limbs are joined to the trunk at the shoulders, and the lower limbs at the hips. The bones of the upper and the lower limbs correspond quite closely to each other in number and arrangement

The Skeleton is the bony framework of the body. It is not all in one piece, as is shown by the fact that we can bend many parts of the body. Each finger, for example, consists of three bones, and each thumb of two bones. The entire skele-



HUMAN SKELETON.

ton contains about two hundred bones of various shapes and sizes. Some are long; some are flat; many are irregular in form.

JOINTS.

The union of two bones is called a joint. Most of the bones are so joined as to allow them to glide upon each other. Some joints permit the bones to move like the hinges of a door, and are therefore called hinge-joints. All the joints of the fingers and toes are hinge joints. In some cases one bone has a rounded end which fits in a cup-shaped hollow in another bone. This is called a ball-and-socket joint, and allows freer motion than a hinge joint. Such joints are found where the legs and arms are fastened to the trunk.

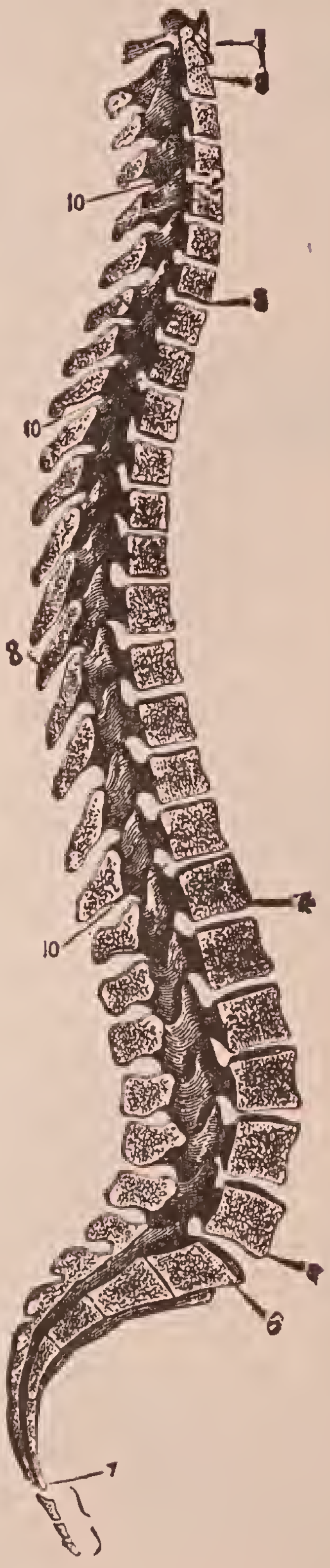
In some joints the bones merely have a slight gliding motion, as in the wrist and the backbone. The movable joints are aided by a fluid which looks somewhat like the white of an egg. The bones which form these joints are held together by strong white bands, called ligaments. When the ligaments are torn or stretched, the injury is called a sprain

In the head, the hips, and other parts of the body, there are a number of joints in which the bones are fastened immovably together. These are called fixed joints.

Structure.—The bones are of a pinkish-white color. They are surrounded by a tough covering, through which nerves and bloodvessels pass into the bones. The outer portion of the bone is generally very hard, while the inner part is somewhat softer. Some of the long bones are hollow and are filled with a soft substance called marrow.

Composition.—A large part of the bone consists of lime, which makes it hard. The remainder is a gristly material which makes the bones tough. By soaking a long, thin bone in weak muriatic acid, the lime will be dissolved and only the gristle will remain. The bone may then be easily bent and even tied in a knot. By burning a bone, the gristle will be destroyed, leaving the lime, which is very brittle. The bones of children consist largely of gristle and are therefore not easily broken. The bones of grown-up people contain more lime than gristle, and for this reason are more liable to be broken.

The Backbone is not one bone, but a column of small bones, held in place by their peculiar shapes. Through the backbone runs a long hollow, which holds the spinal cord and protects it from injury.

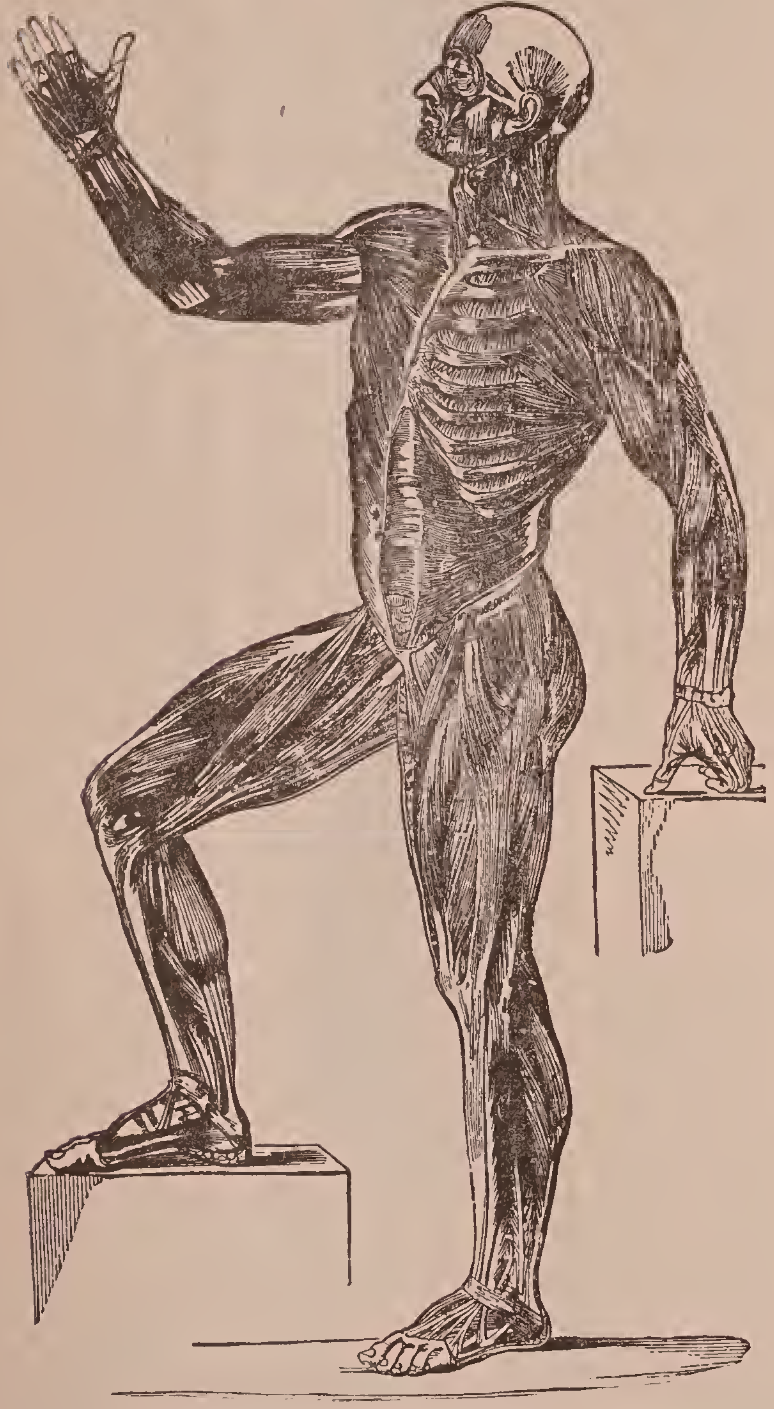


THE BACKBONE.

Since the bones of a child are soft, care must be taken that they are not bent out of shape by sitting or standing in improper positions.

THE MUSCLES.

The fleshy covering of the skeleton is called muscle. If we examine it carefully, we shall find that it is not simply one mass of red flesh, but that there are separate bundles of fleshy fibres. Each of these bundles is called a muscle. The human body contains several hundred muscles. The red meat which we use for food is the muscle of animals.



MUSCLES OF THE BODY—FRONT VIEW.

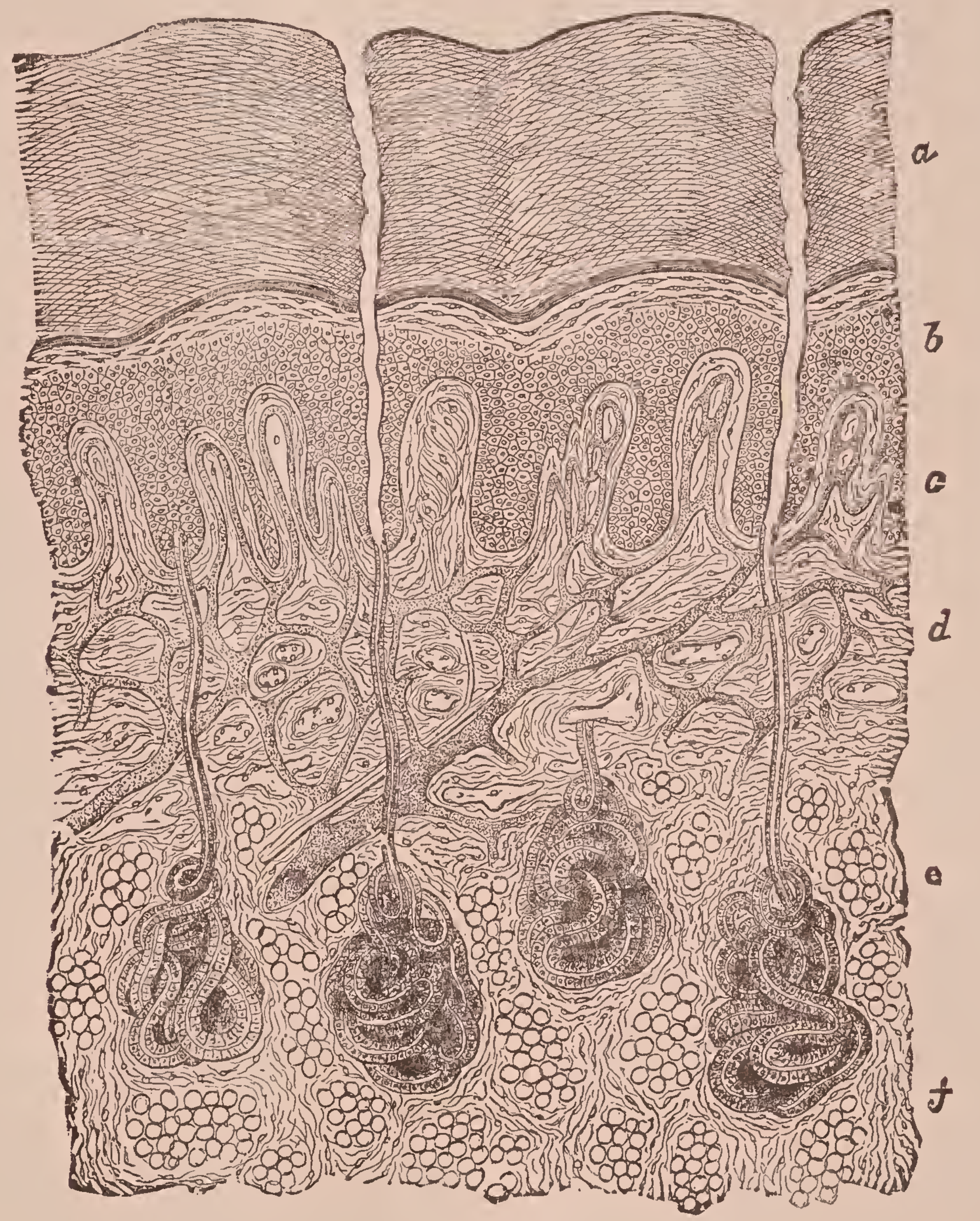
Kinds of Muscles.—Most of the muscles of the body can be controlled by our will. If we will to raise the arm, the muscles produce the desired motion. In the same way we may move nearly every part of the body at will. The muscles which produce these movements are called **voluntary muscles.** On the other hand, there are muscles of whose action we have no control. The heart, which is really a kind of muscle, beats even when we are asleep. No matter how strongly we use our will, we can not by so doing check the action of the heart nor hasten it. Other muscles, mainly acting upon internal organs of the body, are similarly beyond the control of the will. These are called **involuntary** muscles. Some muscles are only slightly under our control. The muscles of breathing, for example, can be stopped for a time, but in a few seconds they resume their action, no matter how strongly we endeavor to check them. In the same way we can hold the eyes open by the action of the will on the eyelids, but in a short time the natural winking will be resumed, in spite of our utmost effort to control these muscles. Such muscles are only partly voluntary.

Size and Shape of Muscles.—Some muscles are very tiny, such as are found in the eyelids. In the arms, the legs and the back there are very large muscles. Most of the muscles of the limbs are thick in the middle and have tapering ends. The heart is a hollow muscle. The shape of the body depends partly on the skeleton and partly on the size, shape and arrangement of the muscles. The walls of the abdomen are almost entirely composed of broad, flat muscles.

Structure of Muscles.—Boil a piece of lean meat until it is tender, and you will be able to pull it apart easily. You will find that it is made up of great numbers of slender threads of muscle which were held together in a tight bundle by connective tissue.

Tendons.—The muscles that close the hand when you make a fist are mainly not in the hand, as you might suppose, but in the forearm. Clasp your left arm just below the elbow and then move the fingers of the left hand. The motion of the muscles can be felt very plainly. How does this motion reach the fingers? These muscles end in long, thin, white cords which run from the arm to the fingers, and move the fingers, just as we may move a door by pulling a string tied to the door-knob. These cords are called tendons. Many muscles end in tendons. The strongest tendon in the body is at the heel, and is used in lifting the foot. Get a turkey leg at Christmas and see whether you can make the toes move by pulling the tendons.

Use of Muscles.—Every movement of the body is caused by muscles. Walking, talking, breathing, writing, each requires the use of certain muscles. This motion is produced in every case by the power which muscles have to change their shape by becoming shorter and thicker. If we release a stretched rubber band, it will shorten and become thicker. Now, suppose this were a strong band with one end fast near the shoulder and the other below the elbow. Then, when the rubber band shortened, the forearm would be pulled upward. In much the same way all the movements of the body are produced.



THE SKIN.

a. Epidermis or cuticle,
b. Dermis or true skin.
c. Nerve prolongation.
d. Blood-vessels.
e. Oil cells.
f. Glands.

Care of the Muscles.—Good food, pure air, and proper exercise are necessary to keep the muscles strong and healthy. When muscles are properly exercised they become strong and hard. The mighty arm of the blacksmith shows what can be done by the constant training of one set of muscles. Active outdoor games furnish the best kind of exercise, but they should not be continued until one is completely tired out. Moderate exercise will develop the muscles much better than heavy lifting, running long distances at high speed, or other feats of strength and endurance.

THE SKIN.

How the Body Is Covered.—Like a close-fitting garment, the skin covers the entire body, hiding the muscles from view and yielding perfectly to every movement caused by them. It is made up of two layers, the outer **scarf-skin** and the inner **true skin.** The scarf-skin contains neither nerves nor blood vessels, and may, therefore, be injured without causing pain or bleeding. The hair and the nails are really modified forms of the scarf-skin. The true skin does contain nerves and blood vessels. Little openings through the skin, called pores, carry the perspiration to the surface of the skin. Other tubes carry a kind of oil, which tends to keep the skin soft, and the hair soft and glossy.

Uses of the Skin.—The scarf-skin protects the sensitive true skin. It is this part of the skin which forms a blister. Every one knows how painful is the slightest touch when this outer layer has been removed. The hair gives additional protection to the head. The nails cover delicate nerves in the toes and fingers. The finger-nails are also of great use in enabling one to pick up small objects. The perspiration helps to keep the body at an even temperature. When we become very warm the perspiration flows freely and cools the body.

Care of the Skin.—In order to keep the body in a healthy condition the pores of the skin must be kept clear so that the flow of perspiration may go on properly. The perspiration contains waste matter, which acts as a poison if it is retained in the blood. If these pores become clogged with dirt the blood can not be as pure as it should be. The importance of having these pores in healthy action is shown by the fact that if a large part of the body is slightly scorched by fire, thus causing the pores to cease acting, death is likely to ensue, An extensive burn is nearly always more serious than a severe burn on a small part of the body.

Cleanliness is of the greatest importance. Some of the terrible contagious diseases that sweep over certain parts of the world are undoubtedly caused by lack of cleanliness. Many cities that were frequently visited by such diseases have been made healthy by being made clean. The germs of disease grow best in filthy surroundings, and attack soonest those who do not give proper care to the matter of personal cleanliness. To be healthy one must be clean.

FOOD AND DIGESTION.

Why We Need Food.—The wonderful machines, which we call our bodies, need fuel to keep their heat and force, repair material to keep them in proper condition, and oil to make them run smoothly. The food we eat furnishes all of these things. Some kinds of food are of special value in keeping the body warm and producing force. Other kinds build up and repair the various parts of the body. The food contains materials for the bones, the muscles, the skin, the brain, and every other portion of the body.

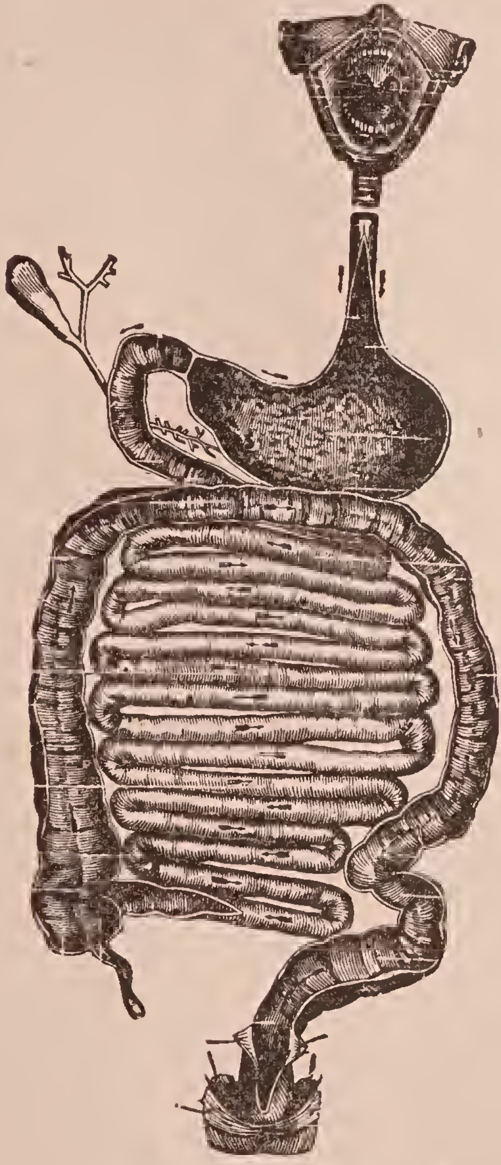
Digestion.—Before the body can use the materials in the food, they must first be changed to blood. This process is called digestion. It begins in the mouth, and is not complete until the food has been acted upon by a number of substances called digestive fluids. The food is finally absorbed by the blood vessels in the walls of the stomach and intestines.

The Mouth.—Here the food is cut and crushed by the teeth, and at the same time is mixed with a digestive fluid called the **saliva.** Then it is pushed to the back part of the mouth and passes through a tube, called the gullet, to the stomach. The **teeth** of an adult are thirty-two in number. They are hard, bone-like objects, with roots that hold them fast in the jaw, and very hard crowns of enamel, which prevent them from wearing away rapidly. They differ in shape and use. Some are shaped like a chisel and used for cutting the food. Others are rather pointed and correspond to the great tearing teeth of a wolf. Still others have broad surfaces suitable for crushing and grinding.

The Stomach.—This organ is situated in the abdomen, just below the diaphragm. It has muscular walls, which produce a sort of churning motion when food is present. From the walls issue a liquid called **gastric juice,** which changes the food into a substance somewhat like gruel.

The Intestines.—From the stomach the food passes into the intestines. These are tubes about thirty feet long, in which the digestion is completed. A slight amount of starchy material was digested in the mouth; the albuminous food, such as lean meat and white of eggs, was digested in the stomach; the intestines act upon all kinds of food. Several kinds of digestive fluid pour into the intestines and finish any work of digestion which the mouth and stomach left incomplete.

Absorption.—The food is now ready to enter the blood. The walls of the stomach and intestines contain thousands of tiny tubes that absorb the digested food and finally pour it into the veins. The change is now complete. The food has become blood and is ready to be carried throughout the body, where each organ will take up the kind of material it needs.



STOMACH AND INTESTINES.

Care of the Digestive Organs.—The cutting, tearing and grinding of the food by the teeth is an important part of digestion. Therefore, the food should not be eaten so hastily that it can not be properly chewed. The **teeth** should receive careful attention. If the enamel is cracked by biting hard substances, picking the teeth with pins, or in any other way, the tooth soon decays. Particles of food that lodge between the teeth should be removed with a soft toothpick. The teeth should be brushed regularly. Prompt attention by a dentist will frequently save a decaying tooth which would otherwise be lost.

Blood Supply.—The digestive organs need a large supply of blood when they are changing food into blood. We should, therefore, not take severe exercise immediately before or after a meal, as this would draw the blood to the muscles. Food should not be eaten between meals. The digestive organs need rest just as the muscles do. Plain food well cooked and not too highly seasoned is easiest to digest. Large quantities of cold water at mealtime weaken the gastric juice, and drive the blood from the digestive organs.

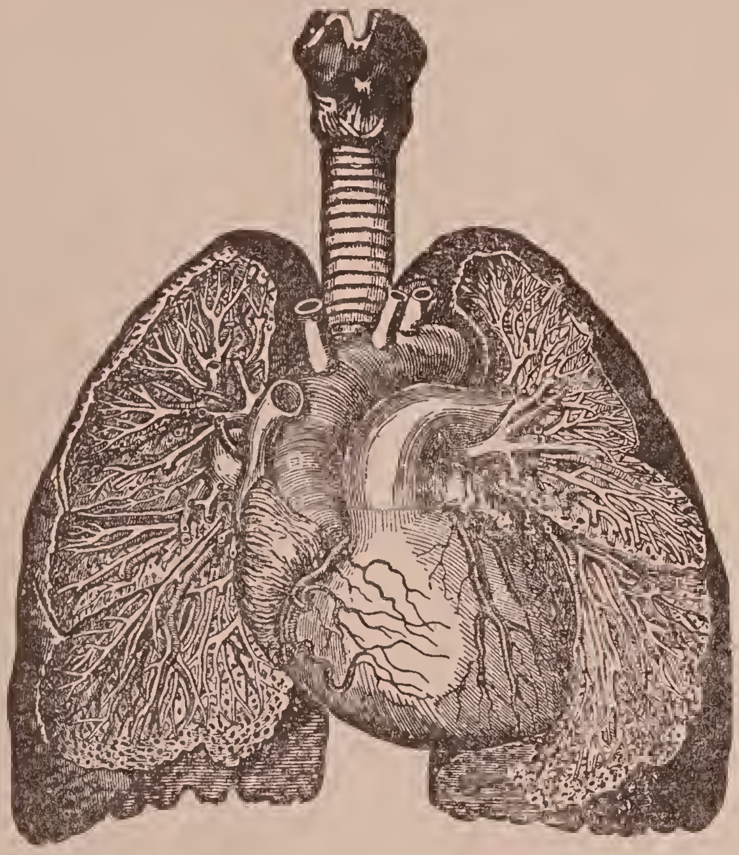
THE BLOOD.

Description.—In the body of an adult there are from six to eight quarts of blood. The blood is about one-thirteenth of the weight of the body. The red color is due to the fact that it contains millions of tiny red bodies, called corpuscles, which are shaped somewhat like a coin. There are also white corpuscles, but they are not nearly so numerous as the red. The fluid in which these corpuscles float is itself almost as clear as water. Some idea of the size of the red corpuscles may be gained from the fact that 3,200 of them placed side by side like pennies would make a line only an inch long.

The Heart and Blood Vessels.—The blood is constantly moving, in some places flowing steadily like a stream, in others passing along in spurts and leaps. The motion is due to the beating of the heart. This is a mass of muscle about the size of one's fist, and is situated in the chest a little to the left of the breastbone. It acts as a sort of double pump. The heart contains four cavities, two on the right side and two on the left. The right side is used to pump the blood to the lungs. From the lungs it flows back to the upper cavity on the left side, and passes into the lower cavity, from which it is pumped to all parts of the body. On its return it pours into the upper cavity on the right side, thus completing a round trip. The heart beats about seventy times a minute.

Arteries.—The blood vessels that carry blood away from the heart are called **arteries**; those that carry blood back to the heart are called **veins.** The blood passes from the arteries to the veins through very tiny bloodvessels called **capillaries.** The blood flows steadily through the veins; it passes through arteries in spurts or bounds.

Why the Blood Circulates.—To furnish the body with the materials it needs, the heart sends out a constant supply of good blood to every tissue and organ. Each of these selects the substances it requires as the stream of blood passes by, and at the same time gives up worn-out material to be cast off from the body. This exchange takes place in the capillaries. It is here that the bright-red, pure blood changes to dark, impure blood. The veins carry this dark blood to the right side of the heart, from which it is quickly driven to the lungs, where the impurities are cast off through the breath. Now, bright and pure again, it returns to the left side of the heart to begin once more its journey to the tissues and organs. When we take exercise the body wears out more rapidly. The heart, therefore, beats faster, sending the blood more quickly with its supply of new material to repair the tissues.



THE HEART AND LUNGS.

Bleeding.—If an artery has been cut, the blood will be bright red, and will issue from the wound in leaps. If a vein has been cut, the blood will be darker and will flow in a steady stream. If the flow is rapid or long-continued, measures should be taken to check it. Remember that arterial blood is traveling from the heart to the extremities of the body. Therefore, when an artery is cut a tight bandage between the wound and the heart, which will close the artery, will check the bleeding. On the other hand, the blood in the veins is returning from the extremities to the heart. The bandage should, therefore, be placed beyond the wound. In less serious injuries bandages may be applied directly to the wound. When blood comes into contact with the air it forms tiny fibres, which form a kind of network over a small cut, and soon hardens sufficiently to close the wound and stop the bleeding.

BREATHING.

Need of Air.—We might live some days without food, but we could live only a few minutes without air. The air contains a substance called oxygen, without which life could not exist. If the supply of oxygen is shut off death quickly follows.

The Organs of Breathing.—The lungs are two large, pinkish bodies that fill most of the chest cavity. They consist of delicate tissues, so arranged as to form numerous air cells and air passages. Within the tissues are thousands of tiny capillaries. The air reaches the lungs through the nose or mouth and the windpipe.

How We Breathe.—The walls of the chest and the diaphragm together form an air-tight chamber, in which the lungs are situated. Muscles that are fastened to the backbone and the ribs are able to lift the ribs so as to make the chest cavity larger. The diaphragm is somewhat dome-shaped. When the ribs are lifted the diaphragm at the same time flattens out, thus giving still more room in the chest. When this occurs the air rushes into the lungs and swells them out to fill the space. When the muscles cease to act the ribs fall, the diaphragm resumes its former shape, and the air is forced out of the lungs.

Why We Breathe.—The blood which comes to the lungs from the right side of the heart contains impurities which must be thrown off. In the capillaries of the lungs these impurities pass into the air spaces and are breathed out. If they were retained in the blood they would act as poisons. At the same time the capillaries take up a fresh supply of oxygen from the air in the lungs. Thus the blood is purified and is ready once more to be sent to the left side of the heart to be sent out to all parts of the body.

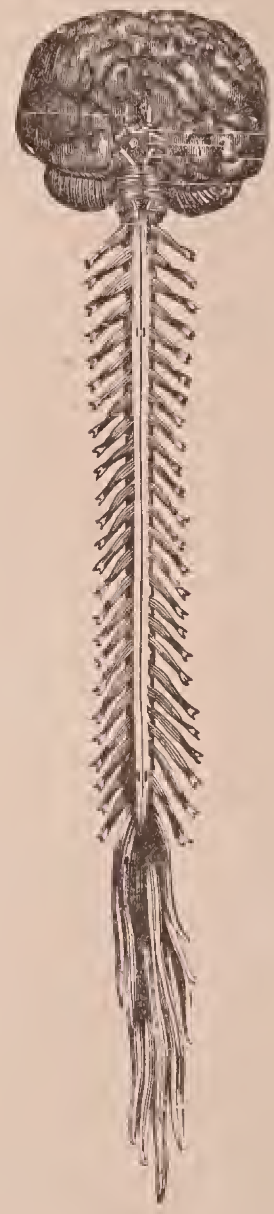
Care of the Lungs.—Since death results in a few minutes when the supply of oxygen is shut off, it is plain that great care is necessary to keep our lungs well supplied with pure air. Our houses and places of business should be well ventilated. Bedrooms should have plenty of air. Do not be afraid of "night air." How could there be any other kind at night? It is much better for you to breathe pure night air from out of doors than foul night air such as is found in tightly closed rooms.

The lungs are very delicate organs. A cold may inflame them and cause dangerous sickness. Therefore, one should be careful not to cool off too quickly when overheated by exercise. Moderate exercise, pure air, day and night, and reasonable care about clothing, draughts, and sudden chilling of the body, will keep the lungs in healthy condition.

THE NERVOUS SYSTEM.

The Parts of the Nervous System are the brain, the spinal cord, and the nerves. The **brain** is a soft, delicate mass, encased in the skull. It weighs about three pounds. It is gray on the outside and white on the inside. There are numerous folds or ridges on its surface. The **spinal cord,** which is a sort of extension of the brain mass, is about eighteen inches long and about as thick as the little finger. It is situated within the backbone. The **nerves** are silvery threads that are connected with the brain and the spinal cord. They divide into innumerable tiny branches, which reach almost every part of the body. The nerves that are directly connected with the brain are called **cranial** nerves, and are mainly found in the face and head. The nerves that are joined to the spinal cord are called **spinal** nerves and extend to the other parts of the body.

The Work of the Nervous System.—Have you ever noticed the telegraph wires that follow the tracks of a railroad? These wires run to a central office and are used to carry messages to and from the superintendent who has charge of the railroad. Without his direction the trains would soon be in confusion and danger. From every part of the railroad system reports are constantly being made to the central office, and the central office is sending out orders in answer to these messages. In much the same way the mind uses the brain as a sort of office, receiving messages and sending out orders through the nerves. A few organs of the body, such as the heart, keep up their work without direct command from the brain, but in most cases there is no action until the orders are issued. The true skin is full of nerve-ends. If we touch a hot stove the nerves immediately carry the news to the brain. Instantly the brain orders the muscles to remove the hand from danger. Thus, the nerves are constantly carrying messages of information to the brain, telling what is occurring to various parts of the body, and the brain is as constantly giving directions to the various organs to do certain things. These messages travel along the nerves at the rate of about one hundred feet per second.



THE BRAIN AND SPINAL CORD.

The Brain is the seat of all our thinking. When one does not think well we believe that he either has a poor brain or does not use his brain well. Just as muscles become strong by exercise, so the brain becomes strong by using it. When the brain is working it needs a large supply of blood. Indeed, the brain uses more blood in proportion to its size than any other organ of the body.

While the brain is usually less than one-fortieth of the bodily weight, it uses about one-eighth of the entire blood supply.

Care of the Nervous System.—To be healthy the nervous system requires moderate exercise and periods of absolute rest. During our waking hours the brain is constantly active, though it works much more vigorously at some times than at others. The brain gets complete rest when we sleep. At this time the brain neither receives messages nor sends out orders. At the same time, only those bodily activities are kept up which are necessary to keep us alive, such as the beating of the heart. Without this period of rest neither the body nor the brain could long remain in a healthy condition. Most people need about eight hours of sleep each day. Children require more sleep than adults.

THE SPECIAL SENSES.

The Five Senses.—The brain is constantly receiving messages from the world around us through five special senses, each of which has some special organ or organs. The sense of sight uses the eyes as a means of gathering knowledge. The sense of hearing uses the ears. The sense of smell is located in the nose, and the sense of taste in the tongue. These four are confined to rather small parts of the body. The fifth sense, touch, is found in nearly every part of the body. From each of these sense-organs nerves run to the brain which have the power to carry only these special kinds of messages. If the nerves of the eyes should be destroyed, sight would be impossible, even though the eye itself should be in perfect condition.

The Sense of Smell is located in the back part of the nose cavity. Here the nerves of smell are spread out in the lining of the nose, so that the air in passing into the lungs when we breathe carries odors directly to these nerves.

The Sense of Taste is most acute in the nerves at the tip and at the back part of the tongue. In order that we may be able to taste any solid substance, it must be soluble in the saliva. Salt, for example, will dissolve in the mouth; therefore, we can taste it. A pebble will not dissolve, and is therefore tasteless.

The Sense of Touch is not confined to some small special organ. Nerves of touch are spread over the skin of the whole body. It is very acute in the lips and the tips of the fingers. In the fingers of the blind this sense is very highly cultivated.

The Sense of Hearing is located in the ear. What we commonly call the ear is really only the outside part of the organ of hearing, and is chiefly useful in collecting the waves of sound and leading them into the inner ear. The nerves of hearing are found in the lining of the inner ear, which occupies a cavity hollowed out in the skull. As the ears are very delicate organs care should be taken not to injure them by picking them with hard objects.

The Sense of Sight is, perhaps, the most wonderful of all the special senses. The eye is shaped like a ball. It is about an inch in diameter and rests in a cavity of the skull. This protects it to some extent from injury. The eyelids, eyelashes and eyebrows give additional protection to this delicate organ. Tiny muscles fastened to the eyeball enable us to move it in various directions. The eye is so constructed that a tiny picture of anything we are looking at is formed at the back of the eyeball, where the nerves of sight are placed. These nerves carry the sensation thus produced to the brain. The eyes are so important and so delicate that they should have great care. We should not read in a poor light, nor should we use the eyes after they become tired. If the eyes are painful or become tired easily one should consult an oculist immediately to see whether eyeglasses are necessary.

This ends the story of the wonderful machine called our body. No one would think of handling a valuable watch carelessly. How much more should we take care of our bodies. A watch may be lost or destroyed and thus merely deprive us of a very useful object; but when our bodies are injured by carelessness or abuse our lives are made miserable by it. No one can hope to be very successful in life unless he has a good, clear brain in a sound, strong body. It may be interesting to know about how our bodies are constructed and how the various organs do their work, but if you want to get the real benefit of this study pay attention to the rules of health and endeavor to have a sound brain in a sound body.

TALKS ABOUT COMMON THINGS

MINERAL THINGS.

Gold.—Gold is one of the few mineral substances that is found in a pure state. But it is mostly found in quartz veins which fill up cracks in older rocks. It is also found in fine grains among the sands washed down by rivers. When thus found it is got by simply washing the sand away with water. When got from quartz, the rock is crushed by a machine, and then washed with water, which leaves the heavier gold behind. Sometimes acids are used to dissolve the gold out of the crushed quartz. Gold is one of the heaviest of metals and is found in all parts of the world. When stamped into shape it is used as money; but being soft it would wear away very fast unless it were hardened by mixing an alloy, or harder metal, with it. It can be beaten into very thin leaves, called gold foil, which are used for gilding picture frames.

Silver.—Silver is a soft, white metal, found in many parts of the world, and mostly mixed with other ores, from which it must be separated by the use of acids. It takes a high polish and is used as money, also for making table-ware, and for coating knives and forks. It is neither so heavy nor valuable as gold.

Mercury or Quick-silver is so called because it looks like liquid silver. It is found in few places, and is hard to obtain. It has to be carried in cast-iron bottles. It is used for making thermometers, and coating the backs of looking glasses. It is a very heavy metal.

Iron.—Iron is found in all parts of the world in the shape of ore. It is the most useful of metals. There are many kinds of iron ores. These ores are purified by burning them in a furnace, and then drawing off the melted iron, which, being heaviest, sinks to the bottom of the furnace. The molten iron is run into little troughs of sand where it hardens. It is then called **pig-iron,** which is again purified in furnaces and rolled in needed shapes of pure iron. When pure iron is hardened it becomes **steel.**

Copper.—Copper is sometimes found pure, but oftener in the form of ore, which has to be purified in order to get the copper. It is a very useful mineral and is found generally throughout the world. It is made into cheap coins, and when mixed with tin it becomes **bell-metal** or **bronze-metal.** When mixed with zinc it becomes **brass.** It is a powerful conductor of electricity, and in the form of wire is used on all electric lines.

Tin.—Tin is found in but few places. Its ores have to be purified in order to get the pure whitish metal, but in the Malay peninsula it is found mixed with the gravel of river valleys, which is gathered and melted by the Chinese laborers. It comes into the market in blocks or pigs, and is chiefly used for coating iron, forming **tin-plate** and making **bronze.**

Lead.—Lead is usually found in an ore, called **galena.** It is chiefly produced in our Western States and in Spain. Lead ore is sometimes very valuable on account of the great quantity of silver mixed with it. It is a heavy soft, gray colored metal, and is most largely used for water-pipes, roofing, machine-fittings, and mixing with other metals as an alloy.

Zinc.—Zinc is an easily melted bluish-white metal. It is found mixed with many kinds of rock, out of which it has to be purified. Moisture does not affect it, for which reason it is used for sheathing and coating iron (then called **galvanized-iron**). It is also used for making brass, britannia ware, and in the manufacture of electric batteries.

Platinum (plat′i-num).—Platinum is a heavy tin-white metal, which can be drawn into thin wire. It has a value between that of gold and silver. It is hard to melt and does not rust like iron. It is used in the shape of foil and wire for many purposes. The main supply comes from Russia, where it was once used for making small coins.

Nickel.—A bright silver-white metal, found largely in Norway, but in small quantities in the United States and Canada. It is found mixed with other substances from which it has to be extracted. It has many uses on account of its freedom from rust. In this and several other countries it is mixed with other metal and coined into small coins like our five cent pieces. It is also much used for plating iron and steel, and for mixing with steel to make armor plate for warships. When mixed with copper, it makes the metal known as **German silver.**

Al-u′mi-num is a white metal with a bluish tinge. It is contained in common clay, and in all minerals of a clayey nature. Its weight is only about one-quarter that of iron. It does not rust like iron. It finds large use in the making of small wares instead of silver or iron.

Sulphur.—Sulphur is really not a metal, though it is thrown out of the ground mixed with metallic substances from the mouth of active volcanoes. It is usually found in a more or less pure state about the base of volcanoes. In the island of Sicily are great sulphur mines of a nearly pure quality. Most of the world's supply of sulphur comes from these mines. It is used for bleaching purposes and in the making of sulphuric acid. It burns with a blue flame and peculiar deadly odor. Sulphur is also used in making gunpowder and matches. When it comes ground fine, it is called **flour of sulphur.** When it comes rolled in sticks, it is called **roll sulphur** or **brimstone.**

Graphite.—This is also known as **plumbago** or **black lead.** It is black and so soft that it leaves a mark on paper. For this reason it finds large use in the making of lead pencils. It is classed in nature as a nearly pure carbon, that is, as something like coal or the diamond. It is also much used on machinery, like oil, to prevent friction and the heating of spindles.

Diamond.—Like graphite, the diamond is classed as a carbon, but purer. It is the most costly and brilliant of precious stones, and is the hardest of known substances. As the diamond is found in nature, it is called a **rough diamond.** For use in jewelry, it is cut into various shapes with many reflecting faces or facets, by which its brilliancy is greatly increased. The diamond is mostly without color, but some are yellow, blue, green, and even black. Diamonds are said to be of the **first-water** when they are very clear and transparent, and of the **second-water** when they are less transparent. At one time nearly all diamonds came from India. During the last century Brazil became the chief source of supply, the diamonds there being found, mostly in the beds of rivers. Since the year 1867, the diamond fields of Kimberley, in South Africa, have furnished most of the diamonds of the world. Many million dollars worth of diamonds are sent each year from Kimberley to London and Amsterdam, where they are cut and polished.

Salt.—Salt is prepared along the coasts of warm countries by placing sea-water in shallow pans or vessels and placing them in the sun, whose heat evaporates or drives off the water, leaving the salt behind. But most of the salt used in this country is got from salt or brine springs, which are found in the earth by boring holes down to a great depth. Some of these bores or wells are said to be from 3,000 to 4,000 feet deep. When a salt spring is thus struck the briny water rises to the top, where it is placed in vessels over fires, which drive off the water leaving the salt in the bottoms of the vessels. Salt is also found in many places in the form of solid rock, which, when broken into small pieces, is called **rocksalt.**

Coal.—Coal is a black or brownish black substance dug from beds or veins in the earth and used for a fuel like wood. Like the diamond, it is a carbon, though not so pure. It is found in many countries. There are several great coal fields or beds in the United States. Coal is formed from wood. Many thousands of years ago when the earth was young and warm, trees grew to great size and in immense forests. When they fell down and became covered with heavy rocks and earth which pressed them together and shut off the air, all their woody parts were driven off or consumed except the carbon which was in them. This carbon grew blacker and harder under heat and pressure, and at last became coal, which, as we have seen, is almost pure carbon. There are many kinds of coal. When it is very hard and shiny, it is called **anthracite** or **hard coal;** when it is soft and without lustre, it is called **bituminous** or **soft coal.** There is also a coal called **lignite** or **woody coal,** which is a carbon still holding much of its woody parts.

Pe-tro′le-um.—This word means **rock oil,** because it was supposed to come from the rocks under the ground. It is also called **mineral oil** and **natural oil.** It is a dark brown or greenish liquid which burns, and is found deep in the earth by digging wells to reach it. When the wells reach the oil, pumps are put in and the oil is pumped to the surface, where it is run into large tanks or vessels for shipment to places where it is to be refined or purified. It is not fit for use until it is thus refined. It is found in all parts of the world, but in greatest quantities in Russia and the United States. The greatest petroleum industry in the world is now seated in the State of Pennsylvania, where the first oil was struck in 1859, while boring a well for brine. We seldom see petroleum in its raw or natural state, because it is carried to the refineries in closed tanks upon cars, or through long pipes placed in the ground. It is only in its refined state that we become familiar with it, and then not as petroleum, but as **coal oil** or **kerosene,** which we burn in our lamps. We also get to know it in the form of **benzine, gasoline, paraffin,** etc.

Asphalt.—This is composed of nearly the same substances as petroleum, but it is thick and does not flow. It is of black or brown color, and burns like coal, only it leaves no ashes. It is found in large natural deposits, as in the Pitch lake of the Island of Trinidad, or in seams of rocks, as in Italy and the United States. When it is purified by boiling, it is known as **mineral pitch.** It is in this form we usually see it. When asphalt is mixed with pitch, lime and gravel it becomes very useful for making pavements and water-proof cement for roofs and bridges.

VEGETABLE THINGS.

Sugar occurs in nearly all vegetable juices.

Sugar-cane came originally from Asia. It is now grown in nearly all warm countries. The cane, when grown, is cut off close to the ground and taken to a mill, where it is crushed to get the juice out. The juice is then boiled to drive off the water. The sugar in its raw state remains. It is then taken to a refinery, where it is refined, and then becomes fit for use on the table. Much sugar is now made from the beet-root, both in this country and in Europe.

Coffee grows in the form of a berry on trees of small size. When the berry is picked off it is covered with a thick, pulpy coat, which is removed after drying, leaving the inside, or real berry, which is again dried and made ready for the market. Coffee originally came from Arabia. Brazil raises more than half the coffee supply of the world. Java ranks next as a coffee grower. The different kinds of coffees take the names of the countries in which they are grown.

Tea is the tender young leaves of a shrub or small tree which grows in China, Japan, India and some other countries. There are several kinds of teas, depending on the size of the leaf and the time of picking. The green leaves are dried very carefully in the sun or with artificial heat. Some leaves are rolled before drying to make them curly. One way of preparing the leaves makes **black tea,** the kind usually drunk in Europe; another way gives **green tea,** the kind mostly used in America.

Cereals.—We call by this name the grasses which have been changed by cultivation until their seeds have become large and fit for human food. Of these **wheat** is the most important. In the form of flour it is the chief food-grain of western Europe and North America. **Barley** is mainly used for brewing beer, and **oats** for feeding horses. **Rye** is a hardy grain, which, in the form of coarse brown flour, is much used for bread-making in northern and eastern Europe. **Maize** (Indian corn) with stalks 7 to 12 feet high and large ears packed with close-set grains, is the one cereal native to America. It is grown to a very large extent in the United States. It makes a wholesome and nourishing food for both man and beast. **Rice** is almost the sole food of many millions in Asia. It grows in low, swampy grounds which can be readily overflown with water. Much rice is grown along the coast of the Gulf of Mexico.

Fruits.—There is hardly any end to the number and kinds of fruits grown in the world. Nearly every country grows fruit suited to its climate and soil. California is the finest fruit-growing State in this country. Nearly all the northern States grow fine apples and other hardy fruits. Fruits can now be shipped very long distances by means of refrigerated rooms in cars and ships. Bananas and pineapples come chiefly from the islands of the Carribean Sea.

Spices, Pepper, before it is grown for table use, is the dried berry of a shrub which grows largely in the islands of the Pacific Ocean, south of India. The same section grows the **nutmeg,** the kernel of a plum-like fruit, and **cloves,** which are the dried flowerbuds of the clove plant. **Cinnamon** is the rolled and dried bark of the cinnamon tree. It comes chiefly from the island of Ceylon. **Mustard,** which is so generally used as a condiment on our tables and also in medicine, is the spicy seed of a bushy plant growing some five or six feet high in many countries, but the chief source of the world's supply is India and Asia Minor.

Drugs.—The bark of the **cinchona** tree, which grows in South America and in the Pacific islands, yields that very valuable medicine called **quinine.** It is used to cure fevers that are the result of malarial poisons. **Opium** is the dried juice of the poppy plant, which is grown largely in Egypt, Persia and India. It is used in medicine, chiefly as a sleep producer (narcotic).

Textile Plants.—Textile really means something that may be woven into clothing. Therefore, textile plants are those whose bark, leaves or other parts yield a fibre that may be spun into yarn and then woven into cloth. Of these **flax** is very important. It is a hardy plant, grown largely in Russia, Germany and the United States. The blue-flowered flax plant grows about three feet high. When ripe it is pulled and steeped in water until the soft parts are rotted away. It is then beaten (scutched) to break up the woody parts and leave the long, tough, fine fibres known as **flax.** These are spun and woven into the article called linen.

Hemp grows in many parts of the world. It is the substance out of which rope and sailcloth are chiefly made. Italy and Russia grow very fine hemp.

Cotton is a soft, downy substance looking like fine wool. It grows in the form of twisted hairs, around the seeds of the cotton plant. This plant grows in all warm countries. The finest cotton is grown in Egypt, but by far the largest amount is grown in the southern part of the United States. The downy hairs around the cotton seeds are separated by a process called **ginning,** and the raw cotton thus obtained is packed in large bales for shipment to all parts of the world to be spun and woven into cloth.

Paper is made from a number of vegetable substances which are ground into a fine pulp. The pulp is then spread thinly on moving blankets which are kept heated by steam, to dry the water out and leave behind the thin, dry paper. In former times only linen rags were used for making paper, but now cotton and woolen rags, wood, straw, and many kinds of grass are used for the purpose. The United States, England and Germany are the chief paper-making countries.

ANIMAL THINGS.

Skins.—Nearly all savage tribes of northern countries use the skins of wild beasts for clothing. The people of civilized countries also use many kinds of skins for warmth. Animals whose skins are thus worn are called **fur-bearing** animals, and their skins, when treated and fitted for wearing, are called **furs.** Among the animals whose skins become valuable as furs are the Siberian **squirrel,** the **rabbit** of Australia, the **musk-rat** and **otter** of North America, the **seal** of Greenland and the North Pacific islands. The **fox, wolf** and **bear** are valuable for their skins. **Lion** and **tiger** skins from Asia and Africa bring a high price. The hides of domestic animals, such as cattle, sheep and horses are used for making leather.

Ivory.—This is got in great amount from the **elephants** in Africa, where, it is said, 65,000 elephants are killed every year. The tame elephants of Asia do not grow very large tusks. A coarser kind of ivory comes from the teeth of the **hippopotamus** in Africa, and of the **walrus** of the Arctic seas. Ivory is made into knife-handles, billiard balls, and ornaments of various kinds.

Feathers.—**Ostrich** feathers came originally from the wild birds of Africa and Arabia, but now the chief supply comes from the tame ostriches raised on the feather farms of Cape Colony in Southern Africa, and of California. The brilliant little **humming-bird** of Central America shares with the **Bird of Paradise** the first place for beautiful feathers for ornament. The down which the **eiderduck** strips from its breast is of great importance. This is collected on the lonely rocks of Norway and Iceland, and made into warm linings and bed-covers.

Wool, from its value as clothing, holds a high place among textile materials. The **merino-sheep** yields the finest kind of wool. The four greatest sheep-raising regions are Australia, Argentine Republic, Russia and the United States. They, together, raise three-quarters of the world's supply of wool. The **Angora goat** of Asia yields a very fine wool, which we call **mohair.** The **camel** in China and the **alpaca** of South America yield a wool which is made into valuable clothing.

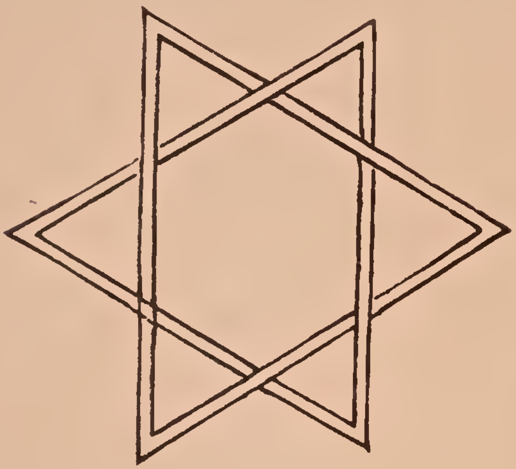
Silk in its first or raw state is the fine, soft thread spun by the silkworm in forming the cocoon (case) in which the worm incloses itself. The cocoons are gathered together and the soft threads are unwound from them upon reels. In this state it is called **reeled-silk,** and is ready to be shipped to the silk-mill to be woven into the cloth we call **silk.** Before the silk-worm begins to spin its cocoon, it is fed on mulberry leaves. The worms must eat about 770 pounds of leaves in order to produce 15 pounds of raw silk.

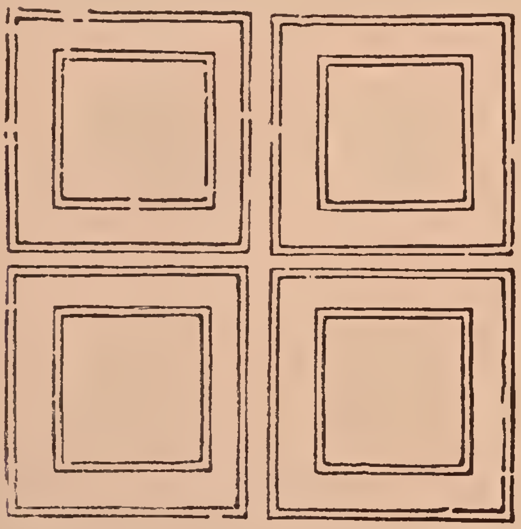
FIRST LESSONS IN DRAWING

DICK'S FIRST TRIAL AT DRAWING.

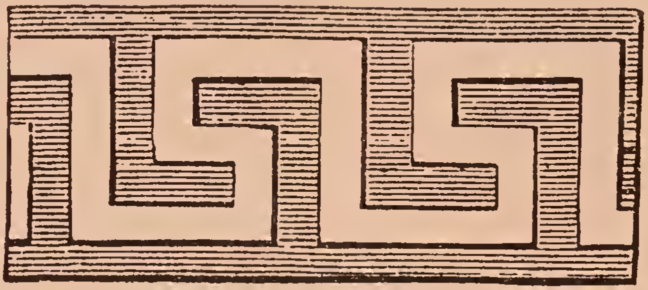
Seeing Things.—Almost everybody would like to draw, but many never learn, because they are afraid to begin. Now, no harm happens if one fails on the first trial at drawing. In fact, no one ever learned the art of drawing until after many trials. In order to draw you must first learn to see what things look like. You may think your fingers need the most practice. Really, the eye needs the most at the start. Anybody can make a stroke, light or heavy, and most people can make a straight stroke; the fingers will make the stroke, if the eye will only tell them what sort of a stroke to make.

Straight Strokes.—People often say they cannot draw a straight stroke. Very likely not; a straight stroke is hard to draw, and the longer it is the harder it is. But this kind of a thing is easy to practice; any clean piece of paper will do, and any spare time may be filled up in drawing straight strokes, at first short ones and then longer ones. These strokes should be all alike in heaviness or thickness. Their length may be measured by drawing the lines on ruled paper between two or more lines. The thickness of the lines depends on the point of the pencil. It should be kept fairly well pointed, and turned around often in the fingers, to keep the point evenly worn. Never hold a drawing pencil too firmly in the hand, nor very close to the point. Rest the arm easily, leaving the wrist free. All this requires practice, just such practice as you would give to playing over the scales, if you were learning music.





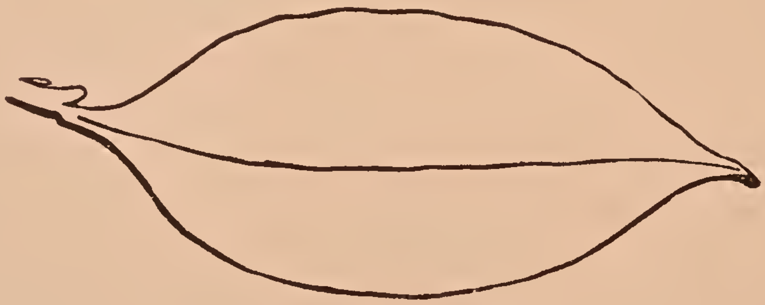
Curved Lines.—After this you must try other lines than straight ones. Try some very simple curved lines, and master them just in the same way you mastered the straight lines. Keep them as light as you well can to make them distinct.



Drawing Natural Objects.—In early drawing practice it is always well to draw easy natural objects. Nearly all such objects give good subjects for practice. Leaves, feathers and shells can almost always be had, and then we can go to animals or parts thereof, and to plants and trees.

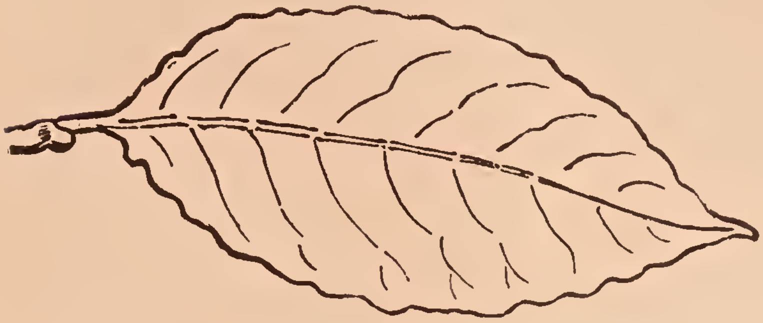
OUTLINE OF A LEAF.

First Step.—Let us now see if you can make the outline of a leaf. Begin with the middle line, which shows the rib of the leaf. Make the line light with a soft pencil. See that it has the slight curve seen in the picture. How long you shall make it depends on what size you have chosen for the leaf you intend to draw. Sometimes the size of your paper will settle this question for you. This middle line or central rib will be your guide to the second step.



OUTLINE OF LEAF—FIRST STEP.

Second Step.—The second step is to make the outer lines on either side of the central rib. These should be lightly drawn, and should show by the curves the general shape of the leaf you have chosen. You may make these lines plain, or you may make them wavy, if the outer edges of the leaf are wavy or rough. When this is done, you draw in the little side ribs, which run out from the main or central rib, taking care to have the curves and directions right. In drawing such an object, or indeed an object of any kind, more is gained than the mere practice of the lines. Much is learned about the objects themselves. You will note that the edges of the leaves and the veins, or small ribs, differ from one another; also, that the sizes and shapes of leaves differ greatly. You thus lay the groundwork for study of leaves, and plants, and trees.

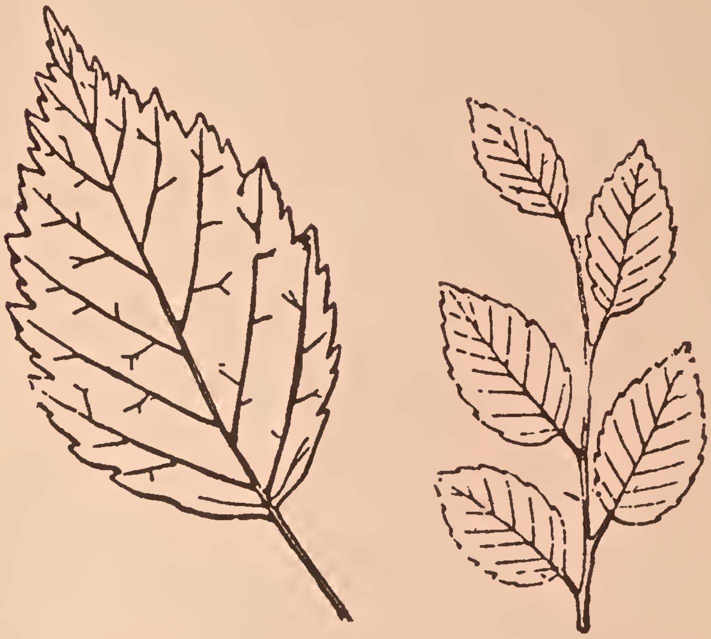


OUTLINE OF LEAF—SECOND STEP.

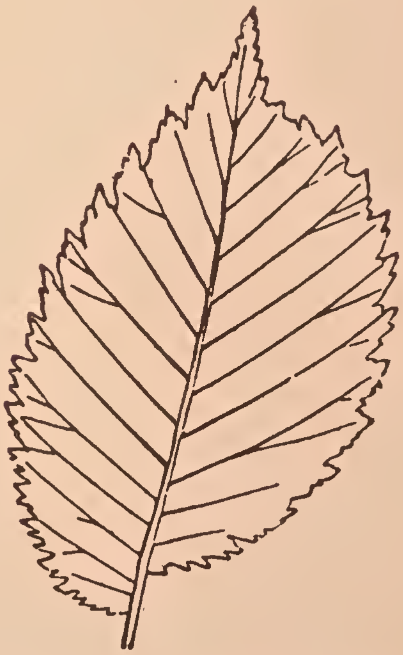
OUTLINE OF HAND FOR PRACTICE.

Never Hurry.—There are many objects besides leaves and flowers which will give you pleasure to draw, if you look into them and give them a little study. Never be put out with yourself if your first trials are not successes; and, above all, never be in too great a hurry. You can never do a thing well if you are in a hurry about it. There is an old saying that "the more haste the less speed." So never hurry, especially at the beginning of a drawing.

Practice Leaves.—For practice drawing no objects are better than leaves. At first you will find large leaves the best, such as leaves of the buttonwood or tulip or oak. Their shapes are very marked and you can see them at a good distance.



OUTLINE OF TREE LEAVES FOR PRACTICE.

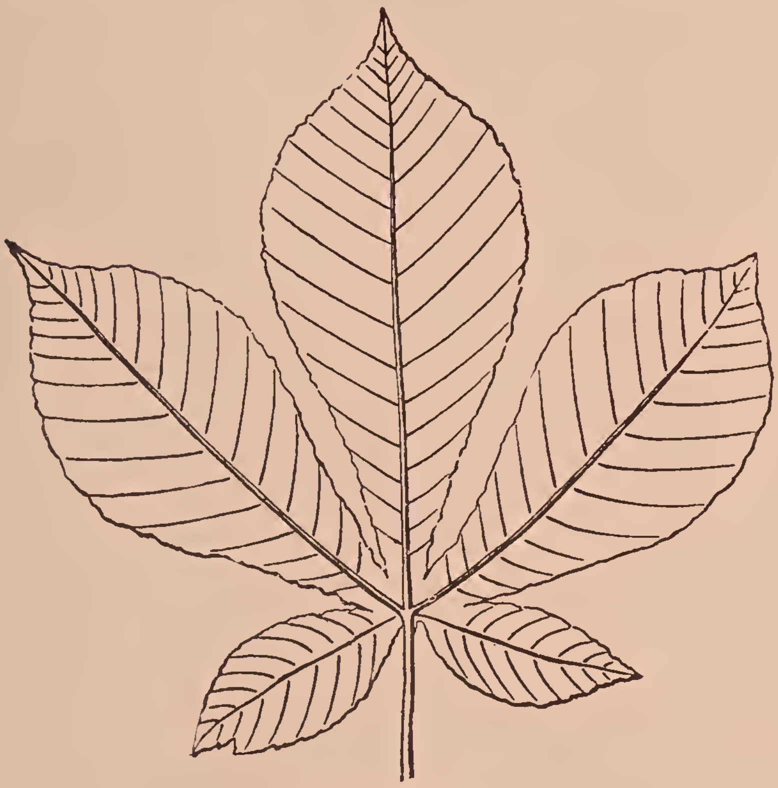


OUTLINE OF TREE LEAF FOR PRACTICE.

When you draw them much smaller than you would if you were drawing only single leaves, the shape is still kept. A little practice will enable you to draw them as small as in the picture.

DRAWING A HORSE-CHESTNUT LEAF.

What beautiful great leaves there are on the horse-chestnut tree! They are like giant hands with five fingers spread out, only the fingers are a funny shape and very thick at the ends. If you notice a horse-chestnut tree on a lawn where the branches hang down, you will see how the great leaves spread out flat to catch the sun and enjoy the showers. In drawing one of these leaves, it would be best to pull it off the stem and take it home and draw it indoors at first. You will need a big piece of paper to draw the leaf on at first, and then you will get all the stems in that run down the leaves. But afterwards you will be able to draw all this just as well much smaller; if you remember what you drew in the large one you can put all the same strokes in in a smaller copy of the same leaf. Now, when you have done this you can go out of doors and draw a leaf or two on the tree itself without pulling it off. Perhaps there will be several leaves together, and you can see the whole of one clearly, and some of the others will be partly hidden. You had better draw the whole leaf first, and then notice how the others fit into it. When you draw half a dozen leaves in this way, you can then try a whole branch. It will not do to begin at one side of your paper with leaves of one size and then work to the other side, and find, when it is done, that you have gone on making them larger and larger until the last are double the size of the first. To prevent this make a faint outline of the general shape of the branch, and do not let any of your leaves go outside of this outline.



A HORSE-CHESTNUT LEAF.

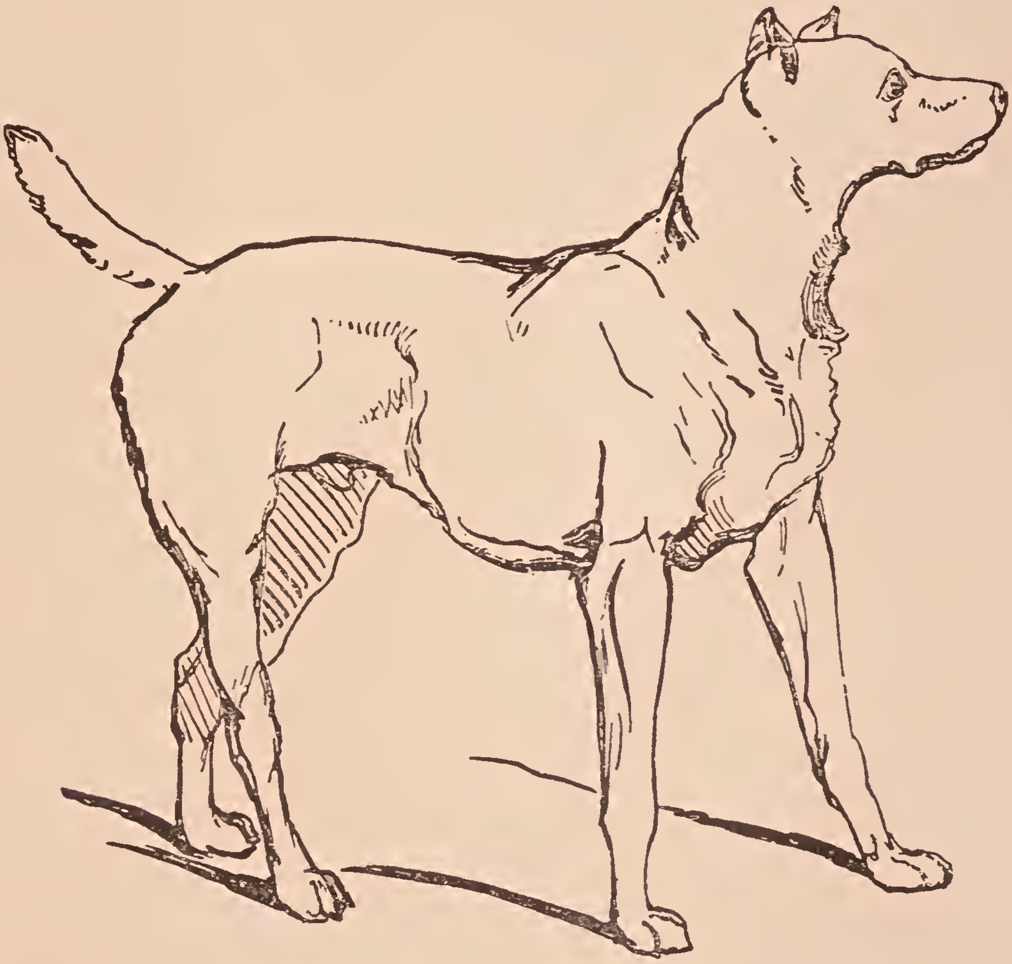
Why the Horse-Chestnut.—We have taken the horse-chestnut in this case because its leaves are large-grained, and when you have learned to draw one well you will not find it hard to add others of the same kind, but other kinds of leaves will give you good practice. A very good bit of practice is to take home a small branch with leaves on it lying in all kinds of directions, some plain open before you, some turned sideways, some looking like mere lines, and some crumpled up in all sorts of shapes. Fasten this branch up in some way, and draw it carefully from more than one position, if you can get the time before it becomes withered. The leaves of trees soon wither, and there is no use putting them in water; they will not last like flowers. If you leave your drawing half done at night you will find that the next morning the leaves have all changed their positions and twisted and curled about so that you would scarcely believe it was the same branch; so it is no use to try to correct your yesterday's drawing by what you find to-day.

Taking Notice.—While you are drawing leaves and branches in this way, be careful to notice the difference between different kinds of trees, and get some one to tell you their names, if you do not know them. And notice, too, how each tree has a different way of putting out its twigs and branches. The stems and bark are all as different as the various leaves.

HOW TO DRAW A HOUSE.

You would like, no doubt, to draw some pretty house or place you are fond of. Some people think this is very easy, and they go and sit down where they can see all the house, straight in front, and they put in all the doors and windows and then are quite satisfied, but it is not the pretty place that you know it to be. Others are so frightened at beginning that they do not know what they are to do, or what size they they must make it, and so give it up. It is really very much like drawing the horse-chestnut leaf and branch, which we have just spoken of; there is no great difficulty about it, if you begin in the right way, and take pains.

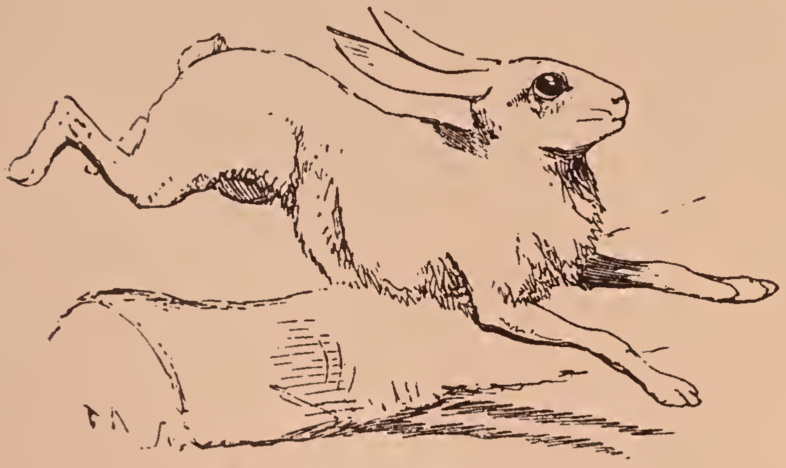
Choice of View.—Begin by choosing the house you want to draw, and pay attention to that. In the horse-chestnut branch we chose out a leaf to begin with. If you want to have a view of the house, you must find some spot where you have a pretty view of it; not too close, because then you will get nothing else, and it is the scenery around it that makes it look so pretty; and not too far off, or it will appear very small. In drawing a house it should not stand in the middle of your picture, but a little to one side or the other of a middle line. After choosing your spot, or view point, you must look at the place as if it were inside of a picture frame, so as to see how much must come into the picture, and how much must be left out. You will want a little view on each side of the house, some trees, a bit of ground, or a little of the road leading up to it. The size you wish to make it will depend on the size of your paper, or on what you can conveniently carry to draw upon. You must now draw or imagine a line across the view you have chosen. The readiest line to take is that of the horizon, where the earth appears to meet the sky. Mark this off in the distances at which the walls of the house, and the grounds, and the trunks of the trees, appear to cross it, and by means of the slopes or angles thus made you can tell how high or how low these lines should run. You now have guides for filling in all the parts of the picture in just the right proportions. You must take pains to do this well, and bring out all the points, as to walls, trees and so forth.



PICTURE OF DOG TO COPY FROM.

HOW TO DRAW A DOG OR HORSE.

It is very pleasant to draw animals. It is hard to draw a dog when he is awake, he is so fidgety. Better begin to draw him when he is asleep. You will then learn the proportions or sizes of the various parts; that is, how big the head is, when compared with the body, and how long the legs are, compared with their own width or the length of the whole animal. Another good way is to begin to draw a bit at a time—the head, the leg, or even the paw—and you can take your time over this. If you cannot get your dog or horse in a good, quiet position for drawing, you can get a plaster cast of such animal, and then draw from this. There are very many such casts of dogs and horses, and some of them very good. Draw first the various parts—forelegs, hindlegs, heads, necks, then the bodies—and when you have learned these almost by heart, you may put them together and draw the whole animal.



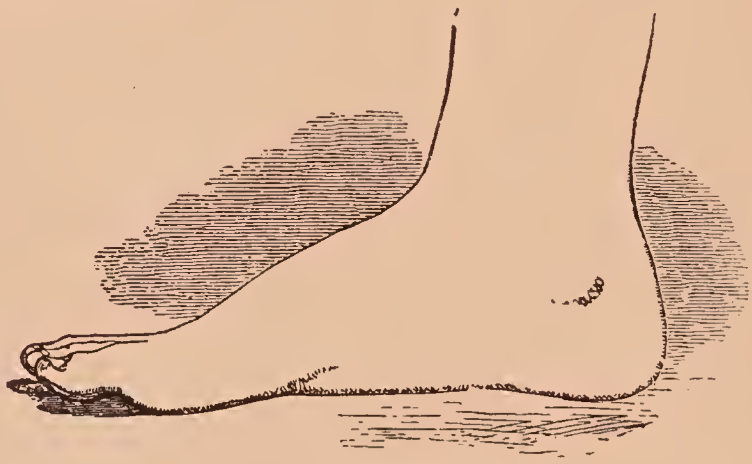
LEAPING HARE TO COPY FROM.

Drawing a Horse.—You will find with a little practice that you will soon be able to draw horses that are alive and moving; for instance, you may draw a horse that is walking, for though it never remains for a single second in the same position, at every step it goes through all the old positions that it had been in before. You have but to remember forms. You may watch animals in motion and draw them in your head, so to speak, and then, when you go home you may put them on paper. As you go along the road you may watch horses walking, trotting and galloping, until you know, as it seems to you, all the motions they go through, and will be able to tell in what order each limb is moved, and even what muscles show themselves as each motion is made.

THE HORSE.

DRAWING A MAN.

Everybody likes to draw a man. About the first thing a child begins to draw on a slate is a man. Almost all the great pictures of the world are pictures of men or women. When you cannot do the whole of a thing, perhaps you can do a piece, and so, if you cannot draw a whole man at first it is well to begin with a piece of a man. You may draw a foot, or hand, a leg or an arm, but the most interesting part of a man is his face, and that we may take to pieces and draw a bit of it at a time—an eye, or nose, or mouth. If you can get a good large copy of some of these parts you will find it will make it much easier to draw from the thing itself afterwards, if you first have drawn it from a copy. You will be able to see lines that you never dreamt of before, if you see them first in the copy.



OUTLINE OF A FOOT.

The Foot.—Suppose, then, we begin with a foot. It will want a little looking at before we can draw it. A little time spent in looking at any object before we begin to draw it is not thrown away, because we are learning what it really **looks** like and what it **is** like. By looking at your own foot you will see nearly straight lines running down the sides, that the heel stands off from these straight lines, and that the five toes form a nicely curved outline, bearing due relation to one another.

In looking further at your own foot you can see the place and shapes of the bones inside of it. We do not see the joints in all the toes equally well, but they all have the same number of joints, except the big toe, which, like the thumb, has one joint less. Then you will see that the toes all join together and form the instep of the foot, but the instep is not made of one big bone: it has five separate bones running up from each of the toes. Above the instep are several bones which you cannot see from the outside until you come to one bone where the foot fits on to the ankle, and after this you have two bones which form the leg. The more you know about these things which give shape to the foot the better you can draw one. In the meantime, draw your own foot, or a baby's foot, as it lies kicking about on the floor.

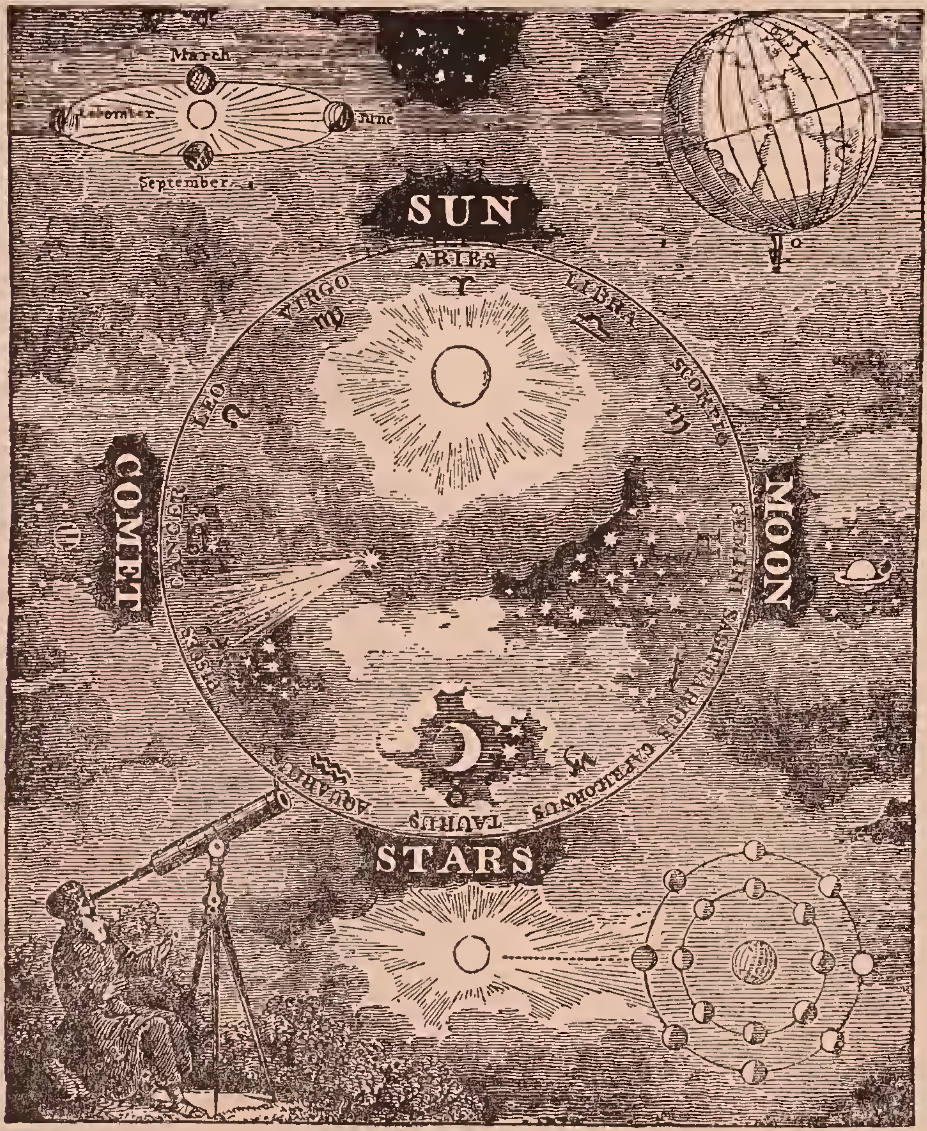
The Hand.—What has been said about the foot applies equally to the hand, and as you come to draw them both you will soon find how much there is alike in the hands and feet, the bones being the same in number, but not quite alike in shape. It is much easier to get hands to draw than feet, and so you may often get somebody to hold out a hand, quite still, for you to draw from when you could not get a foot.

SOMETHING ABOUT DRAWING A FACE.

This must be done, like the whole body, by drawing it bit by bit. Draw eyes, right eye and left eye, and then both together, and when you draw them together be quite sure that they match and that both look in the same direction. If you look sharply enough you will find a line running right across the face through the middle of the eyes, cutting the corners. If you mark off on this line an equal quantity for each eye and get the little black spot in the middle of the eye (this spot is called the pupil) in the same part of each line, your eyes ought to go right then. In the same way you must practice mouths, looking for a line across between the lips, above and below which line the lips will bend up and down at equal distances on each side of the middle. The nose and upper lip want practice of the same kind, and when each part has been to a certain extent learned by heart, then the whole may be put together in proper proportions. There must be a line down the middle of the nose and through the middle of the mouth and chin. This line is gently curved if the face is turned a little sideways to us. Across this will run the line through the middle of the eyes, a little more than a third of the way down; then the nose will end about two-thirds of the way down, and a line will run across the mouth about one-third of the remainder; the eyes and the various curves of the mouth will be equally distant from the centre. In the same way the various portions of the body all have their regular measurements or proportions, different, of course, as individuals differ in size and shape.

We wish our young friends to do their best to practice drawing. Do not draw when you are tired, but if you do not get tired, work at it steadily, but not too much, every day, and always do your best. You will soon learn enough to give yourself great pleasure, and in time you are sure to give other people pleasure too.

SUN, MOON AND STARS—Astronomy



THE SUN.

The sun is to us the most important star or orb in the sky. It is not solid so far as we can tell, but is a mass of white-hot vapor, and shines by reason of its own light, which cannot be said of the planets and stars, which shine only by sending back (reflecting) the light they receive from the sun, just as a mirror reflects (sends back) your face when you look into it.

Shape and Appearance.—It is supposed to be round in shape, like the earth, but not flattened at the poles. Mr. Nelson, an astronomer, says that with the help of an instrument, called the **spec-tro-scope,** it is not hard to form an idea of the surface of the sun, which is all we can see. It is like a heavy, thick air (atmosphere) which is heated very hot, and which, at times, is blown about by storms and whirlwinds, crossed by many currents, and now and then broken by violent explosions. Above this bright, burning surface is another, which is not so thick nor hot, though hot enough to shine brightly. This outer surface we cannot see on account of the brighter surface beneath it.

Sun Spots are hollows in the sun's vapory surface, and are very large. They are always changing. They pass from east to west across the sun, and then come again at the east to go over the same space again. This fact seems to prove that the sun turns on its own axis like the earth. Herschel saw a sun-spot which was 50,000 miles across, or more than six times the diameter of the earth.

Distance and Size.—As nearly as we can now measure, the distance of the sun from the earth is about 92,000,000 of miles. This distance is less in winter than in summer, yet we feel less heat. The sun weighs about 1,253,000 times more than the earth. It appears to go around in the heavens in 365 days, 6 hours and 9 minutes, but in reality it takes that time for the earth to go around the sun.

Power of the Sun.—The sun by his power of attraction balances the planets and keeps them in their places. He gives us the light and heat we enjoy, also the rain and dew. No action could go on upon the earth without the sun.

THE MOON.

The moon is called a sat′el-lite of the earth, because it is the one planet which revolves around the earth. The soft light of the moon is really prettier to the eye than the brighter light of the sun. In old times, before the telescope was invented, people thought the moon shone by her own light, and that large creatures lived upon it; but now, by looking through a telescope, we are shown mountains, and the craters of volcanoes. Even with the naked eye we can see upon the face of the moon when it is full dark objects of irregular shape, which some fancy to be seas or maps. Others see in them the shape of a man's face—the "Man in the Moon."

What Might be Seen.—If we could reach the moon we would find its surface very irregular and rough—plains and mountains without water. We would be able to see the stars in daytime, because there is no air (atmosphere) around the moon as around the earth. Silence would reign everywhere. We would find no people, and no plants and flowers, because there is no rain nor moisture on the moon. It is a dead world.

Beliefs About the Moon.—In most countries people believe the moon in its changes controls the growth of plants. In China the people believe the shadows on the face of the moon are a rabbit. The Italians say that wicked Cain lives in the moon with a dog and a thorn bush. The poet, Longfellow, in his poem of Hiawatha, tells what the good Indian, Nokomis, said when asked about the moon:

"Once a warrior very angry,
Seized his grandmother, and threw her
Up into the sky at midnight.
Right against the moon he threw her,
'Tis her body that you see there."

Motion and Size.—The moon moves around the earth in 27 days, 7 hours and 43 minutes. It is a curious thing that it takes just as long a time for the moon to turn around (revolve) on its own axis. For this reason it always presents the same face to us; that is, we can see only one side of the moon. The moon's diameter is about 2,160 miles, or one-fourth that of the earth. Its distance from the earth is about 238,833 miles.

THE MOON AS SEEN THROUGH A TELESCOPE.

Changes of the Moon.—While the moon is going around the earth, there is a time when we cannot see it at all, because it is directly between the earth and sun, and the sunlight strikes it only on the back, or side opposite to the earth. This is called the "dark of the moon." In a few days we begin to see the moon in the shape of a curve (crescent). This is because the sunlight is beginning to strike it on the side next to the earth. Please do not forget that the moon gives off no light of its own, but is seen only by means of the sunlight which is reflected from its surface to the earth, just as a mirror reflects back your face. When the moon is seen in this crescent form, it is called "new moon." Each night the crescent gets broader, and finally the half of the moon is lit up. This is called "half moon." Then it gets fuller and fuller each night until the "full moon" appears, because it is then on the side of the earth opposite to the sun and reflects the full sunlight shining upon it. After full moon it begins to grow crescent again, and more so every night, until it again goes out of sight in its dark stage or phase. It takes the moon 29 days, 12 hours and 44 minutes to go through its changes or phases, so that the moon travels thirteen times around the earth while the earth is going once around the sun.

Eclipses.—There are eclipses (darkenings) of both the sun and the moon. Sun eclipses come only when the moon is dark or new; moon eclipses come only when the moon is at its full. The reason is that the sun is eclipsed when the moon passes between it and the earth; and the moon is eclipsed when the earth passes between it and the sun. Eclipses are not always total, but may be partial. Some are ring (annular) eclipses; that is, a ring-shaped portion of the eclipsed orb may be seen around the eclipsed central part. Eclipses do not come very often. Their coming is known a long time beforehand, for astronomers can compute the time to a minute when the sun, earth and moon will be in such position toward one another as to cause an eclipse.

THE SOLAR SYSTEM.

Solar means belonging to the sun. **System** means part of a thing gathered or grouped together as a whole. The sun, the planets which move round it, comets and meteors make up what is called the **Solar System**. The sun is the centre of that system, and all the planets, comets and meteors move (revolve) around him. The sun holds them all in their places by a law called **gravity**. If you take a string and tie a weight to the end of it, then hold the other end in your hand and whirl the weight around in a circle by the string, it tries to get away; but the string holds it to its place in the circle. Gravity acts just like the string. It keeps the planets in their circle around the sun. In going around the sun the planets appear to be first on one side of it and then upon the other. Therefore they are called **wanderers** (planets). The sun itself is called a planet, for it is believed that he, with all his great company of planets, is revolving around some other great centre in the heavens, though we do not know just where that centre is.

Appearance.—Can you tell a planet from a star? Yes. When you look at a star you see it twinkling in the heavens; but planets do not twinkle. They shine steadily. All planets shine only by means of light borrowed from the sun, which they reflect, or give off, like a looking-glass. They are spheres; that is, they are round like the earth. It takes a planet a certain length of time to go around the sun. This time is called its year. So, it takes a planet a certain length of time to turn around on its own axis. This is called its day. By reason of these turnings (revolutions) planets are constantly changing their appearance and place in the heavens, just as we see the moon doing. Some planets have smaller planets (satellites) moving around them. The moon is the small planet which turns around the earth and keeps it company.

Names and Sizes.—We will now speak of the larger planets. There are eight of them, which are spoken of as "principal or primary planets." We begin with the one nearest the sun. Its name is:

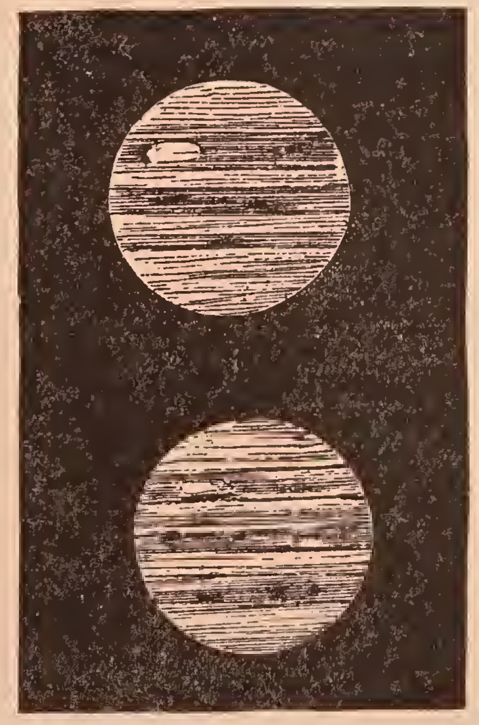
Mercury.—Its distance from the sun is less than half that of the earth, or about 35,000,000 miles. Therefore it receives more light and heat than the earth does. Its day is about 24 hours long; its year is 88 days long; its diameter 3,000 miles. Being so close to the sun, it is a hard planet to see. But it can be seen with the naked eye before sunrise and sunset in the fall and spring of the year, when the weather is clear.

Venus.—This planet comes next in order, its distance from the sun being about 67,000,000 miles. Its year is a little over 224½ days long; its day, or one turn on its axis, is 23⅛ hours; its diameter 7,800 miles. It is the nearest planet to the earth, and is, as you see from the above, only a little smaller than the earth. It is both a morning and evening star, and is very brilliant.

Earth.—The third planet in order is our own earth. We have already described the earth as our dwelling-place in the article called "Story of the Earth," which you have no doubt studied carefully. But it is no harm, in speaking of the earth as a planet, to repeat here that its distance from the sun is about 92,000,000 miles; its year is about 365¼ days long; its day nearly 24 hours long; its diameter nearly 8,000 miles; its circumference nearly 25,000 miles. It turns on its axis from west to east at a rate of nearly 19 miles a second. The passage of the earth around the sun gives us our four seasons—Spring, Summer, Autumn and Winter.

Mars is sometimes called "the red planet," because of its color. Its size is about half that of the earth, its diameter being about 4,200 miles. Its year is 687 days long; its day is 24½ hours long; its distance from the sun about 141,000,000 of miles. It turns its full face toward the earth, and can therefore be easily seen. In appearance Mars is very like the earth, and what are supposed to be seas, canals and continents can be seen upon it through a telescope. It is attended by two satellites or moons.

Jupiter is the fifth planet in order. It has been called the "Giant Planet" on account of its great size. Its diameter is 85,000 miles, or nearly eleven times that of the earth. It moves round the sun at a distance from it of 476,000,000 miles and in about 4,332 days, which make the length of its year. It turns on its axis in a little less than 10 hours, which is the length of its day. Through a telescope Jupiter is seen to be crossed by belts or zones of vapor, which are continually changing their color. It is also attended by four moons which revolve around it, and suffer eclipses just like our own moon.


JUPITER.

Saturn is the most curious of all the planets, being surrounded by rings and attended by eight satellites or moons, which revolve around it. The diameter of Saturn is 70,000 miles; its distance from the sun nearly 880,000,000 miles; its year, or time of revolution around the sun, is 10,759 days, or about 29 of our years; its revolution on its axis, or its day, 10¼ hours.

SATURN.

Uranus.—This planet is sometimes called "Herschel" after the man who discovered it in 1781. Its diameter is 33,000 miles. It revolves around the sun at the very great distance of 1,800,000,000 miles, and its year, or time of such revolution, is nearly 84 of our years. Its day, or time of turning on its own axis, is 9½ hours. It is attended by four satellites, or moons.

Neptune is the furthest from the sun of all known planets, its distance being 2,775,000,000 miles; and its year, or time of one revolution around the sun, is nearly 165 of our years. It is about 37,000 miles in diameter. We cannot as yet tell exactly the length of its day, or time of revolution on its axis.

Other Planets.—The planets described above are called **primary** planets, because they are the largest. Besides these there are nearly 200 minor or lesser planets, some of which go by the name of **asteroids**. An asteroid means a "starlike orb or body." All these minor planets have been discovered within the last hundred years. They are all smaller than the earth, some of them being very tiny. They do not appear to have any satellites, or moons, but themselves move round the sun at various distances and in different times, ranging from 1,100 to 3,000 days.

Meteors.—These are small bodies which rush rapidly through the solar system and get fiery hot in so doing. Some of them reach the earth in the form of metal, but most of them are burned entirely up in their swift passage. The meteors called "falling stars," which we often see at night, are burned out before they reach the earth.

Comets are supposed to be masses of burning gas, with long, fiery tails, millions of miles in extent. They wander through the heavens with very little regularity, and are very beautiful objects to look at, but a constant source of fear to timid people, lest they should strike the earth and destroy it. Some comets make a regular revolution around the sun, and their coming can be foretold by astronomers.

THE FIXED STARS.

The stars are called **fixed** or stationary because they do not appear to the eye to move about in the heavens like the planets do. Yet they have a motion of their own, but it is very hard to find out just what that motion is on account of their great distance from us. As we have seen, we can tell a star from a planet by its twinkle. Planets do not twinkle.

Number of Stars.—No one knows how many stars there are. They can be seen by millions through a telescope, but only about 6,000 can be seen by the naked eye, and of these only about 3,000 can be seen at any one time. More can be seen in the southern than in the northern hemisphere. Stars are all very distant from the earth—so far, indeed, that it is next to impossible to measure how far they are away, or how large they are. Professor Russell calculated the distance of the nearest star to the earth to be sixty-two and a half trillions of miles. They are supposed to be suns, each with its group or system of smaller stars, pretty much like our solar system; only the starry system is called the **stellar** system.

Star Groups.—In olden times those who studied the stars grouped them together into clusters which they called **constellations.** They fancied that these constellations looked like men or animals, and they gave them names accordingly; thus one group, or constellation of 66 stars, was supposed to look like a ram. It was therefore called **Aries,** which means a ram. Another was called **Taurus,** which means a **bull.** There are 141 stars in **Taurus,** so situated as to look somewhat like a bull. One of the small clusters in Taurus is called the Pleiades or "Seven Stars." Another constellation was called the **Great Bear,** because it was supposed to shape up like a large bear. It is also known as the **Dipper** from its shape. Its two end stars are called **Pointers,** because they are in line with the North Star and point to it. There were twelve of these great constellations, or clusters, which the ancients called the signs of the zodiac, or heavenly animal belt. We still call them by their ancient names.

The Milky Way.—When the sky is clear there can be seen stretching across it at night a bright tract or belt which for a long time puzzled astronomers. But it has been discovered by means of powerful telescopes that it is composed of countless stars which are very distant from us and very close together—so close, indeed, as to give that appearance of a solid, bright belt. Sometimes the Milky Way is called the **Galaxy,** which means a milky or whitish way.

HOW NATURE WORKS—CHEMISTRY

AN EXPERIMENT WITH SUGAR.

Put a spoonful of sugar into a glass of water and stir it briskly until the sugar disappears. What has become of it? Is it still in the tumbler or has it been destroyed? Taste the water and you will notice that the sugar is still there, though you can no longer see it. We say it has been dissolved by the water. Heat the water until it has all been evaporated, and you will again see the sugar in the bottom of the vessel. Pour more water upon it and it will dissolve again. Throughout all the changes which occurred it remained sugar to the very end.

AN EXPERIMENT WITH LIME.

Now dissolve a little slacked lime in water: You must use a very small quantity, if you wish to make all of it disappear, as water will dissolve only about one-seven-hundredth of its own weight of lime. You can make lime water more easily by using plenty of lime, stirring it thoroughly, and then letting it settle. The undissolved lime will be at the bottom. The water above it will be clear, but contains some dissolved lime. Pour off this clear lime water into a bottle.

CHANGING LIME INTO CHALK.

Put a tube in the limewater, and blow your breath through the tube for a time. Now look at the water. Notice the tiny white flakes floating there and gradually settling down to the bottom of the bottle. Something strange has happened to the lime, for now you can not dissolve these tiny specks, no matter how hard or how long you stir the water. You have turned the lime into chalk, and chalk is not soluble in water. In your breath there was a substance called carbonic acid gas. When you blew through the tube this gas touched the lime and united with it to form a substance different from the lime and from the carbonic acid gas.

PHYSICAL AND CHEMICAL CHANGES.

When the sugar and the lime dissolved in the water, we called the change in their condition a **physical** change; but turning the slaked lime into chalk, a different substance, was a **chemical** change.

WHAT IS CHEMISTRY?

Chemistry is the science that teaches how two substances may be combined to produce another substance different from either of those of which it is composed. Chemists point out carefully the difference between a **mixture** and a **combination** of two substances. We had in the bottle a mixture of lime and water. The chalk was, however, not merely a mixture, but a **combination** of lime and carbonic acid gas.

Water.—Water itself is a combination of two gases called oxygen and hydrogen. By the use of electricity it is possible to change the water into these two gases and to collect each of them in a bottle. When we examine these separately we find some surprising facts. Hydrogen burns so fiercely that unless special care is taken it will explode. Oxygen is necessary to cause burning. So we have the strange contradiction that while water is used to put out fires, it is composed of oxygen which causes burning, and hydrogen which burns very readily. Indeed, if you have the proper appliances, you can produce water by burning hydrogen in oxygen.

Hydrogen is one of the lightest of all gases. It is only one-fourteenth as heavy as air. For this reason it would be just the thing for filling balloons, if it were not so expensive to manufacture. As it is, balloons are usually filled with ordinary gas, such as we burn in our houses. This is not nearly so good as hydrogen, but is much cheaper. Hydrogen gas may be obtained in small quantities by putting scraps of zinc in water and then adding a little hydrochloric acid. Bubbles of hydrogen will at once rise through the water. By inserting a cork with a tube running through it the hydrogen may be drawn off into another bottle. When water is decomposed, we find that the volume of the oxygen is about half that of the hydrogen. Oxygen forms about one-fifth of the atmosphere, which is a mixture of this gas with nitrogen and some other gases.

Combustion.—The burning of wood, coal, oil, and other common substances is simply the combination of those substances with the oxygen of the air. If the combination takes place rapidly, we have a hot fire. If we wish to make the fire in the stove burn more briskly, we open the air-holes below the fire, so that more air, and therefore more oxygen, may reach the glowing coals. In pure oxygen the burning becomes exceedingly rapid. Light a match, blow out the flame, and thrust the glowing wood into a tube of oxygen; the match instantly bursts into flame again. A lighted candle placed in a jar of pure oxygen burns with a brilliancy that reminds one of an electric light.

Slow Combustion.—Oxygen combines with some substances quite slowly under ordinary conditions. When iron is exposed to damp air, oxygen slowly unites with it and forms rust. The combination occurs so slowly that no heat can be detected.

Bodily Heat.—Strange as it may seem, our bodies are slowly burning. The warmth of our bodies and all our movements are due to a gradual burning of our tissues. At every breath we draw into the lungs fresh supplies of oxygen, which passes into the blood and is carried to all parts of the body. The burning goes on more rapidly when we exercise vigorously. We breathe more deeply and rapidly, in order to bring into the body a larger supply of oxygen, and the heart beats more rapidly, thus sending the oxygen more quickly to the tissues. This explains why we become so warm when we work or play vigorously. Do you remember the experiment with the breath and the limewater? The carbonic acid gas in the breath is a result of the burning of the body. The same kind of gas passes off from the fire in a stove or the flame of a lamp.

No Burning Without Oxygen.—If we shut off the supply of oxygen, the burning ceases. Fires are often put out in this way. Have you ever heard of smothering a fire by throwing a heavy piece of carpet upon it? The fire goes out simply because the carpet shuts off the supply of oxygen. Fires in the interior of ships are often checked or put out by shutting out all air from the burning materials. Fires in mines are often extinguished in the same way. You know how quickly a person will die if his supply of air is cut off. A human being cannot live where a candle will not burn freely, for both the person and the candle must have oxygen to keep up the burning. Sometimes the oxygen is crowded out of the bottom of a well or a mine by other gases. In this case it would be death to a man to enter such a place. To avoid danger, men frequently lower a lighted candle in a place of this kind before entering it. If the candle continues to burn freely, the men may safely enter . If it burns dimly or goes out, the place can not be entered until the foul gas has been driven out and oxygen supplied in its place.

CHEMICAL AFFINITY.

Some time ago Tom and Harry were walking down the street together. As they turned a corner they met Will and John. All of these boys were friends, but Tom and John were especially fond of each other, while Will and Harry were particularly good friends. So it was very natural that after the four boys had stood in a group talking together for awhile, Tom and John went away together, while Will and Harry went away in another direction. Chemical substances show likes and dislikes for each other in somewhat the same way. For instance, we saw in the beginning of this study that carbonic acid gas had a liking, or **affinity**, as the chemist would say, for lime, and that when the two substances met they united to form chalk. But lime has a still stronger liking or affinity for sulphuric acid than it has for carbonic acid. So if we pour diluted sulphuric acid on chalk, the sulphuric acid and the lime unite to form sulphate of lime. It is a case of "two is company, three is a crowd," for neither of these two substances will now have anything to do with carbonic acid and it flies off in the form of gas.

Take a piece of chalk and throw it into some vinegar, and you will see the carbonic acid flying off in bubbles. Lime has a stronger affinity for vinegar, that is, acetic acid, than it has for carbonic acid, and so, as in the other experiment, the lime deserts its former friend, the carbonic acid, and unites with the vinegar to form acetate of lime.

The chemist takes advantage of these affinities to make new substances. Some of the changes which are thus brought about are very remarkable.

Making a Solid Out of Two Gases.—Put into a tumbler a few drops of ammonia, and into another tumbler a few drops of hydrochloric acid. The odor which arises from each of the two tumblers is due to the rising of gas from the substances we put into them. Cover both tumblers with paper and invert one tumbler over the other. Now slide out the pieces of paper that separate the two gases from each other. Notice the cloud of white particles which forms at once. After a time these settle down in the lower tumbler. The two gases have united to form a solid substance called sal-ammoniac, such as is used to charge batteries for electric bells.

Making a Gas Out of Two Solids.—Rub together a little sal-ammoniac and a little unslaked lime. The odor of ammonia will soon be very noticeable. The two solids have united to form ammonia gas.

Making a Solid Out of Two Liquids.—Dissolve in a little water about an equal bulk of chloride of lime. Pour slowly into this liquid some strong sulphuric acid while stirring constantly. In a very short time these two liquids will unite into solid "plaster of Paris," the substance from which our common blackboard crayons are made.

CHEMICAL ELEMENTS.

We have found that water is a combination of two substances called oxygen and hydrogen. It is an easy matter for the chemist to separate water into these two gases; but no one has ever been able to separate either oxygen or hydrogen into two or more simpler substances. The chemist gives the name element to every substance which cannot be separated into simpler substances. In all, there are about seventy known elements. Some of them are very plentiful; others are exceedingly rare. Below is given a list of the most familiar elements:

Metals.—Aluminum, calcium, copper, gold, iron, lead, mercury, nickel, potassium, silver, sodium, tin, zinc.

Non-metals.—Arsenic, carbon, chlorine, hydrogen, nitrogen, oxygen, phosphorus, sulphur.

All of these metals are solid at ordinary temperatures, with the exception of mercury, which is a liquid. All of the non-metals are also solid, except chlorine, hydrogen, nitrogen and oxygen, which are gases.

Every substance on the earth is made of one or more of the seventy elements. Common salt, for example, consists of chlorine and sodium; sugar is composed of carbon, hydrogen and oxygen.

The scientists have found a way by which they now know that the same elements that are found on the earth are also present in the sun, the moon, and the planets. There is strong reason to believe that all the heavenly bodies are made up of the same elements. Occasionally, meteors, or shooting stars, drop from the sky to the earth. Many of these have been analyzed by the chemists, but no new elements have ever been found in them.

Aluminum is very abundant, but is never found in a pure state. It is usually separated by electricity from the substances with which it has been combined. It is a white metal and can be highly polished. As it is very light and strong, and is not affected by the air, it is a very useful metal for making ornaments, cooking utensils, and scientific instruments.

The clays from which various kinds of pottery are made are combinations of aluminum with other elements. From the finest clay we obtain porcelain. Stoneware is made from a less pure quality of clay. Common red bricks and fire-brick are made from low grades of clay.

Calcium is not found in a separate state in nature. It is the metal present in lime, which is simply a combination of calcium and oxygen. Lime is made from common limestone by burning it in a sort of furnace called a limekiln. It is often called quick-lime. When a mass of lime is sprinkled with water it becomes so hot that the water turns to steam. The lime changes into a powdery substance called slaked lime. The ordinary mortar used in building is a mixture of slaked lime and sand. Cement is made of lime and clay. When mixed with water it quickly hardens to a solid mass, even under water. Large buildings and bridges are now commonly made of cement.

Copper is sometimes found in a pure state, but more commonly it is combined with other substances. In the Lake Superior region copper is found in enormous quantities. The metal is extensively used in the form of wire for carrying electricity. It is also used for boilers, cooking utensils, and roofing. Bronze consists of about nine-tenths copper and the remainder tin. Brass consists of copper and zinc. German silver contains copper, zinc and nickel.

Gold is commonly found in the metallic state; sometimes in lumps called nuggets, but more frequently in tiny particles scattered through quartz rock. It is a very heavy metal, being about nineteen times as heavy as water. It is quite soft and can easily be hammered out into thin sheets. Gold is not affected by either dry or moist air. It is largely used for the making of ornaments, and is the commonly accepted money metal. Its softness makes it necessary to combine it with other metals in using it for these purposes. The gold coin of the United States contains one part of copper to every nine parts of gold. When gold is pure it is said to be twenty-four karats fine. Gold eighteen karats fine is therefore eighteen-twenty-fourths or three-fourths pure.

Iron is generally found in combination with other substances, from which it is separated by subjecting it to intense heat in the presence of limestone, and afterward reheating and working it in puddling-furnaces. Iron weighs about seven times as much as water. If two pieces of iron are heated to a white heat, they may be united into one piece by hammering; this is called welding. Heated iron may be rolled into sheets or bars by passing the metal between steel rollers. What we call tin is really sheet-iron covered with tin. Galvanized iron is made by dipping sheet iron into melted zinc. Steel is iron containing a certain proportion of carbon. If steel be heated and then allowed to cool slowly, it becomes as soft as iron, but if when heated to redness it is suddenly cooled by plunging it into cold water, it becomes very hard. This process of hardening or softening steel is called tempering. Try the effect of slow cooling and sudden cooling on a watch spring or clock spring or steel wire.

Lead is a metal with a brilliant lustre, which soon is dulled, however, by exposure to the air. This is readily seen by cutting a piece of lead with a knife. It is so soft that it can be scratched by the finger-nail. Lead is commonly used in the form of sheets for lining tanks and covering roofs. Water pipes in houses are frequently made of lead. Shot is made by running melted lead through a sieve and letting the drops fall from a height into water. The type used by printers, and the solder used by plumbers are mainly composed of lead.

Sodium is a white metal, with a bright surface which, however, tarnishes very quickly. Nearly two-fifths of common salt consists of sodium. It is so soft that it can be moulded like putty, and is lighter than water. When a small piece of sodium is thrown into water, violent chemical action begins at once, causing a hissing noise, and sometimes ending with an explosion. Sodium burns with a yellow flame, which can be seen when common salt is thrown into the fire.

Potassium may be obtained from wood ashes. In many respects it resembles sodium. In contact with water it causes such strong chemical action as to set fire to some of the hydrogen in the water. Burning potassium has a flame of violet color.

Mercury is sometimes found in the metallic state, but more commonly in an ore called cinnabar. It is a very heavy, white liquid. It is used for thermometers, because it will not easily freeze. It is used in silvering mirrors, and is of much value in separating gold and silver from their ores.

Nickel resembles silver in appearance, and can be highly polished. It forms about one-fourth of the metal in our five-cent pieces, the remainder being copper. It is very largely used for plating other metals.

Silver is usually found in combination with other metals. Its brilliant, white surface will not tarnish when exposed to pure air. It is, however, very quickly affected by sulphur. Housekeepers know how soon coal gas, eggs, mustard, rubber, or other substances containing sulphur will blacken silver. Silver is widely used in the making of tableware and jewelry, and furnishes a large part of the metallic currency of the country.

Tin has a silvery appearance and is extensively used in coating other metals. What we commonly call tinware is sheet-iron coated with tin. Copper is frequently coated with tin. The coating process consists of dipping these metals into a bath of molten tin. Tin foil is commonly used as a wrapping for candy, tobacco, etc.

Zinc is found in the shape of ore. When pure, it is a whitish metal, which may be rolled or hammered into sheets or drawn into wire. It is extensively used in making galvanized iron, which is simply sheet-iron dipped into molten zinc. Brass is an alloy of zinc and copper. Large quantities of zinc are used in electric batteries.

Arsenic, in a pure state, consists of brilliant metallic crystals, which soon tarnish in contact with the air. A small quantity of arsenic is commonly added to the lead in the making of shot for the purpose of hardening the shot. The poisonous green coloring matter, known as Paris green, is a compound of arsenic and copper.

Carbon exists in several forms and in many combinations. The diamond, the most highly-prized and costly of precious stones, is simply a crystal of pure carbon. By applying great heat we may change a diamond into a sort of coke in a vacuum, or may burn it like coal, if it is surrounded by oxygen. The diamond is the hardest known substance.

The lead in pencils is a mixture of clay with another form of carbon, called graphite. Coal and charcoal consist largely of carbon.

Chlorine is a yellowish gas with an unpleasant odor. It has such a strong affinity for other elements that it is never found in a free state in nature. Common salt, which is a combination of chlorine and sodium, is known to the chemist as sodium chloride.

Hydrogen is a gas without color, taste, or odor. It is the lightest substance known and is, therefore, particularly valuable for filling ballons. If hydrogen be mixed with about three times its volume of air, the mixture will explode with great force if brought in contact with a flame. Hydrogen may easily be obtained by pouring diluted hydrochloric acid on zinc. Bubbles of hydrogen immediately begin to pass off. Hydrochloric acid is composed of hydrogen and chlorine. Chlorine has a stronger affinity for zinc than for hydrogen. It, therefore, unites with the zinc and the hydrogen is thus set free.

Nitrogen is a gas. It has neither color, taste, nor odor. It weighs about fourteen times as much as hydrogen. Air is a mixture of oxygen and nitrogen. Nitrogen unites with other elements to form various substances. Ammonia is composed of nitrogen and hydrogen. The laughing-gas used by dentists is a combination of nitrogen and oxygen.

Oxygen has been dealt with under the subject of combustion. Like hydrogen and nitrogen, it is colorless, tasteless, and odorless. It has quite a strong affinity for most of the other elements.

Phosphorus is soft and waxlike. It has such a powerful affinity for oxygen that it will burst into flame in the open air at ordinary temperatures. It is used in great quantities in the manufacture of matches, being united with other elements. The head of the match is so near the burning point that the slight heat caused by striking the match is sufficient to produce combustion.

Sulphur, or brimstone, as it is often called, is sometimes found in a pure state, but more commonly in combination with other elements. It is a brittle yellow substance, and is used in making matches, gunpowder and many other substances.

In this brief chapter, only a few of the main features of chemistry could be treated. It is a fascinating subject, and will well repay further study. We owe to the chemists a very large part of the comforts and conveniences of modern life.

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